

## Contributions to our knowledge of Indian algae-III. Euglenineae— Part 2.

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**Abstract.** An illustrated account of six species and ten varieties of the genus *Lepocinclis* Perty and thirty-nine species and ten varieties of the genus *Phacus* Duj from inland waters of north-east, central and south India collected during 1937-76 together with their distribution in the Indian region is given.

Of these, three varieties of *Lepocinclis* (*L. lefevrei* var *cuttackensis*, *L. elongata* var *minor* and *L. playfairiana* var *minor*) and one species of *Phacus* (*P. mammillatus*) and four varieties (*P. balatonicus* var *major*, *P. acuminatus* var *barrackporensis*, *P. caudatus* var *major* and *P. ranula* var *brevicaudatus*) are considered new. Two species and two varieties of *Lepocinclis* (*L. spirogyra* Korsh, *L. steinii* Lemm, *L. steinii* var *suecica* Lemm. and *L. ovum* var *verrucosum* Prowse) and twelve species of *Phacus* (*P. lefevrei* Bourr, *P. nannos* Pochm, *P. wettsteinii* Drez, *P. textus* Pochm, *P. carinatus* Pochm, *P. formosus* Pochm, *P. obolus* Pochm, *P. ranula* Pochm, *P. sesquitortus* Pochm, *P. atrakoides* Pochm, *P. glaber* (Defl) Pochm. and *P. hispidula* (Eichw) Lemm. and one variety (*P. ranula* var *africana* Bourr) appear to be new records for the Indian region.

Although 13 taxa of *Lepocinclis* (5 species and 8 varieties) and 79 taxa of *Phacus* (61 species and 18 varieties) have been reported previously from the region there are only a few reports which give full details. Some of the records also appear to be doubtful.

Keys to the taxa of the two genera described and lists of other taxa of the genera reported from the region are also given.

Latin diagnosis of *Euglena tuba* Carter non Johnson emend. Philipose 1982 is given to validate the species. Three additional species, viz *E. orientalis* Walton, *E. elastica* Prescott and *E. clara* Skuja are also described, the last being a new record for India.

**Keywords.** Periplast; striae; verrucae; pharyngeal cleft, paramylum; cyst; Indian algae; Euglenineae.

### 1. Introduction

This account is the second in the series on Euglenineae, part one being on the genus *Euglena* Ehr (Philipose 1982).

The earliest record of organisms belonging to *Lepocinclis* Perty and *Phacus* Dujardin from the Indian region is that of *Euglena longicauda* Ehr by Grant (1842) which is in all probability *Phacus longicauda* (Ehr) Duj or one of its varieties. Carter (1856, 1856a) reported *Lepocinclis* spp, and referred to the occurrence of *L. texta* (Duj) Lemm (as *Crumenula texta* Duj) and *Phacus pleuronectes* (OFM.) Duj from Bombay. The former is regarded by some authors as *Euglena texta* (Duj) Huebner. Carter (1859) again recorded *Lepocinclis ovum* (Ehr) Lemm (as *Euglena zonalis* Carter) and *L. fusiformis* (Carter) Lemm (as *Euglena fusiformis* Carter). Bhatia (1930) recorded three species of *Phacus* from Kashmir. Skvortzov (1937) reported five taxa of *Lepocinclis*, including two new species, and fifteen taxa of *Phacus*, including a new species and a new variety, from Rangoon. Some of these have been referred to other species and varieties by later authors. Philipose (1940) recorded a species of *Lepocinclis*

and seven taxa of *Phacus* from Museum Pond, Madras. Gonzalves and Joshi (1946) observed three taxa of *Lepocinclis* and one of *Phacus* at Bombay. Skuja (1949) gave accounts of 2 taxa of *Lepocinclis* and 15 taxa of *Phacus* from Burma, of which one of the latter was a new variety. Biswas (1949) stated that *Phacus pleuronectes* was a common organism found in the plankton of Indian inland waters.

In an account of the Euglenineae from Hyderabad, India, Suxena (1955) described two taxa of *Lepocinclis* and eighteen taxa of *Phacus* of which two varieties of the latter were new. Philipose (1960) reported that a number of species of *Lepocinclis* and *Phacus* commonly occur in Indian inland freshwaters. Naidu (1962, 1966) described 13 taxa of *Phacus* from Andhra Pradesh. Kamat (1961-62) recorded three taxa of *Lepocinclis* (including a new variety) and 11 taxa of *Phacus* (including two new varieties) from Ahmedabad. Again, Kamat (1963, 1964, 1968, 1974, 1975) and Kamat and Freitas (1976) reported the occurrence of four taxa of *Lepocinclis* and thirty-nine taxa of *Phacus* (including a new species and a new variety) from Maharashtra. One of the species reported by Kamat and Freitas (1976) is *L. texta*. Kamat (1967) also recorded one species of *Phacus* from Rajasthan and five species of the same genus from Himachal Pradesh (Kamat 1968a). Singh (1948) reported *Phacus hameli* All et Lef from Uttar Pradesh and Hirano (1966) two species of *Phacus* from Kabul, Afghanistan. Hortobágyi (1969) described two taxa of *Lepocinclis* and six taxa of *Phacus* from three reservoirs on the river Jamuna, Uttar Pradesh. Kachroo (1960), and Singh and Saxena (1969) recorded *Phacus pleuronectes* in West Bengal and Uttar Pradesh respectively, and Zafar (1959) and Munawar (1972) in Andhra Pradesh. Seenayya (1972) reported two species of *Phacus* from the same State. Bharati and Hosmani (1973) and Hosmani and Bharati (1975) recorded *P. caudatus* Huebner and *Lepocinclis ovum* respectively from Karnataka. Hosmani (1976) also described a new species of *Phacus* from the same State. Suxena *et al* (1973) described four taxa of *Lepocinclis* and six taxa of *Phacus* from Kerala. Venkateswarlu (1976, 1981) reported one species of *Lepocinclis* and three species of *Phacus* from Andhra Pradesh. Subba Raju and Suxena (1979) recorded *Lepocinclis ovum* and *Phacus indicus* Skv from the Himalayas. Patel and Waghodekar (1981) described 23 taxa of *Phacus* from Gujarat. Ashtekar (1982) reported one species of *Lepocinclis* and 15 species and 4 varieties of *Phacus* from Aurangabad, and Trivedy (1982) 4 species of *Phacus* from Rajasthan.

Altogether 13 taxa of *Lepocinclis* covering 5 species and 8 varieties, and 79 taxa of *Phacus* comprising 61 species and 18 varieties have so far been recorded from the Indian region. In a study of Euglenineae of north-east, central and south India during 1937-76, the author came across a large number of taxa of *Lepocinclis* and *Phacus*, some of which have already been referred to earlier (Philipose 1940, 1960). A detailed account of 16 taxa of *Lepocinclis* (6 species and ten varieties) and 49 taxa of *Phacus* (39 species and ten varieties) is given here of which a few are new and a few others new records for the Indian region. The total number of *Lepocinclis* actually add up to about 22 (7 species and 15 varieties) and that of *Phacus* to 96 (seventy-three species and twenty-three varieties) for the Indian region. This is excluding synonyms and those taxa which are doubtful.

While most of Kamat's records and those of a number of other workers remain in the form of lists or names referred to in ecological studies, without accompanying descriptions or figures, some of the taxa reported by Naidu (1966) appear to be doubtful. Figures given by Patel and Waghodekar (1981) for their twenty-three taxa of *Phacus* are in a number of instances either too small or not quite typical. It has,

therefore, been considered necessary to give detailed descriptions and figures for the taxa reported here.

## 2. Locations and dates of collection

The collection centres are the same as given in Part I (Philipose 1982). A few additional locations not included therein are given below:

2.1a *Assam*: (4a) Joyasagar N P 23 (30-5-55); (5a) N P 16 (6-4-55); (17a) N P, Jorhat (25-10-59); (18a) sdo's tank, Nazira (15-6-55).

2.1b *W. Bengal*: (26a) Tank D, Belgharia (27-6-50); (27a) Sagore Dutt Pond-2, Kamarhati (30-5-50); (33a) Mukherjee's Pond, Hooghly (22-11-49); (36a) Akchara bund, Chandrakona Road (17-12-52).

2.1c *Bihar*: (37a) River Dehri at Hurka Nala (23-5-53).

2.1d *Madhya Pradesh*: (40a) Duatia Pond, Goharganj (20-7-54); (43a) Rajabanda, Raipur (21-4-56).

2.1e *Orissa*: (45a) Treasury tank, Balasore (20-12-52); (55a) Municipal tank, Mayurbhanj (21-12-52); (77a) Ananda Sagar Pond, Narasingpur (17-12-54); (84a) Pond, Athmalik (14-4-56); (90a) B. Sagar, Sonapur (17-12-54); (93a) Pond, Subba Island, Kausalyagang (10-4-51); (100a) Public tank, Jeypore (19-2-57).

2.1f *Andhra Pradesh*: (103a) Dyke's Tank, Visakhapatnam (4-12-54); (104a) Dhobi tank, Narasingpatna (5-12-54); (111a) Gajjala Tank, Ellore (7-12-54); (112a) Vellapadia Tank, Kakinada (5-12-54); (112b) Cheedila Tank, Kakinada (6-12-54).

2.1g *Karnataka*: (130a) K R Sagar drain pool, Mysore (8-2-53); (131a) Well-4, Nandi Hills (6-2-53); (133a) Chandracharis Pond, Coorg (9-2-53).

2.1h *Kerala*: (137a) Canal with *Lemna*, Manjaliparamp, Azhicode (29-9-51); (142a) Mankuzhikulam, Azhicode (26-2-49).

2.1i *Tamilnadu*: (152a) Pond, Chetput Fish Farm (February 1943). Locations 5a, 6, 29, 93, 127, 131 and 136a were particularly rich in *Lepocinclis* spp. and 6, 23, 28, 29, 33, 61, 63, 93a, 131 and 136a in *Phacus* spp.

As already stated, fish ponds receiving organic manures and public ponds which were organically polluted showed large numbers of various species of *Lepocinclis* and *Phacus*.

## 3. Systematic account

### A. Genus *Lepocinclis* Perty 1852

Single-celled and free-swimming by rotatory motion; cell ovoid to ellipsoid or spindle-shaped, rarely spherical; periplast firm and rigid with spiral or sometimes longitudinal

striae, very rarely smooth; with a single flagellum which is usually longer than the body; vacuolar system as in *Euglena*; eye-spot near the reservoir; chromatophores numerous, parietal, discoid or irregularly polygonal and without pyrenoids; paramylum usually two large lateral ring-like refractory bodies, rarely small spherical or rod-like; nucleus median or in the posterior half. Mostly in freshwater.

*Key to the taxa described*

I. Periplast with striae

(A) Striae longitudinal

- (a) Cell elongate-spindle shaped with hind end drawn out into a short tail and front end capitate; paramylum 2, ring- or shell-like; cell  $35-39-64 \times 7.9-10-17 \mu\text{m}$  ..... 1. *L. marssonii*
- (b) Cell fusiform to ellipsoid with apex truncate; paramylum usually 2-3 ring-lets. With short tail having no basal bulge; cell  $22-30 \times 7.5-17 \mu\text{m}$  ..... 2. *L. steinii*  
Tail with a basal bulge; cell  $20-30 \times 9.5-15 \mu\text{m}$  ..... var. *suecica*

(B) Striae spiral

(a) Striae from left to right

Anterior orifice slightly towards one side; cell ovoid with numerous granular to rod-like paramylum; cell  $36-60 \times 26-45 \mu\text{m}$  ..... 3. *L. salina*

(b) Striae from right to left

Anterior orifice apical; paramylum usually 2 rings, rarely otherwise.

- (i) Cell ellipsoid to ovoid and usually with a short tail; cell  $20-38 \times 13-23.5 \mu\text{m}$ ; tail up to  $7 \mu\text{m}$  ..... 4. *L. ovum*  
Cell usually ellipsoid; tail with a basal bulge; cell  $30-42 \times 17-24 \mu\text{m}$  ..... var. *buetschlii*

Cell regularly ellipsoid; tail very small and acuminate or knob-like; cell  $14-24 \times 5-15 \mu\text{m}$  ..... var. *dimidio-minor*

Cell ovoid and with a small conical tail; striae finely punctate; cell  $27-28 \times 20-21 \mu\text{m}$ ; tail up to  $3.7 \mu\text{m}$  long ..... var. *punctato-striata*

Cell ovoid; paramylum disc-like and more than 2; cell  $21-23 \times 16-17.5 \mu\text{m}$  ..... var. *discifera*

Cell ellipsoid to ovoid with a sharp pointed tail; membrane with fine spiral verrucae; cell  $33-35 \times 15-17 \mu\text{m}$  ..... var. *verrucosum*

- (ii) Cell small and ovoid with a short teat-like tail; striae finely beaded; paramylum 2 rings; cell  $21-30 \times 12-17 \mu\text{m}$  ..... 5. *L. lefevrei*

With more than 2 paramylum and 2-3 rows of lightly beaded striae between two strongly beaded rows; cell smaller,  $20-23 \times 10.5-11.5 \mu\text{m}$ ; tail up to  $2.6 \mu\text{m}$  ..... var. *cuttackensis* var. *nov*

- (iii) Cell spindle-shaped with a fairly long conical tail; cell  $52-54 \times 23 \mu\text{m}$  ..... 6. *L. elongata*

Cell smaller,  $32.5 \times 17.5 \mu\text{m}$  ..... var. *minor* var. *nov*

- (iv) Cell lemon-shaped and with a short teat-like tail;  $25-51(-58) \times 12-39 \mu\text{m}$  ..... 7. *L. fusiformis*

Cell smaller,  $14-21 \times 8-11 \mu\text{m}$  ..... fa. *lemmermannii*

- (v) Cell elongate and spindle-shaped with anterior end often broader; tail fairly long; striae markedly beaded; cell  $53-68 \times 16.5-20-30 \mu\text{m}$  ..... 8. *L. spirogyra*



## (II) Periplast smooth and without striae

Anterior orifice not apical

Cell broadly ellipsoid with a well-developed slightly oblique tail; anterior end beaked; paramylum 2 rings; cell  $35.6-40-50 \times 17-28 \mu\text{m}$ ; tail  $10-16 \times 4 \mu\text{m}$  . . . .

.....9. *L. playfairiana*

Cell and tail smaller; cell (with tail)  $28-30 \times 13.7-14.7 \mu\text{m}$ ; tail  $3.7-4.5 \mu\text{m}$  long

.....var *minor* var *nov.*

1. *Lepocinclis marssonii* Lemm. emend. Conrad 1935 (figures 1a-b)

Conrad 1935, pp. 14-15, figure 4; Huber-Pestalozzi 1955, p. 140, figure 119; = *L. marssonii* Lemm. 1905; 1910, p. 508, figure 20 (p. 483); Allorge *et* Lefèvre 1930, p. 130, figures 77-78.

Cell elongate-fusiform with the anterior end drawn out into a beak and the posterior end gradually tapering to a tail; membrane hyaline, colourless and longitudinally striated; paramylum two, lateral and ring- to shell-like; cell  $35-63.5 \times 7.9-11.3 \mu\text{m}$ ; tail alone  $5.3-9.4 \mu\text{m}$ .

*Habitat*: Stray in locations 26a and 30; common in location 136a.

The organism agreed well with the typical species except that lower limits of length were less, and it was narrower than the dimensions given by Conrad ( $39-64 \times 10-17 \mu\text{m}$ ) and Lemmermann ( $39-40 \times 11-13 \mu\text{m}$ ). The tail was also more clear cut than in Conrad's figures. In this respect it showed a certain resemblance to *L. marssonii* var *elongata* Bourrelly (1961, pp. 202-203, plate 4, figures 6-7) with dimensions of  $45-53 \times 8-9 \mu\text{m}$ , but the tail did not arise from a basal bulge as in Bourrelly's variety.

*Distribution in Indian region*: Maharashtra (Kamat 1975); W. Bengal and Kerala (!).

2. *Lepocinclis steinii* Lemm. emend, Conrad 1935 (figure 2a)

Conrad 1935, p. 17, figure 7; = *L. steinii* Lemm. 1904; 1913, p. 134, figure 220.

Cell fusiform to ellipsoid; anterior end nearly entire or drawn out into a beak with the very end indented or flattened; with a short conical tail; membrane usually deeply coloured and with longitudinal parallel striae which are uniform or alternate ones thicker; chromatophores numerous, small and polygonal to round or discoid; paramylum 1-3 ringlets or small ovoid granules; eye-spot fairly large; cell  $23 \times 10.5-11 \mu\text{m}$ ; tail alone  $2.5 \mu\text{m}$

*Habitat*: Stray in locations 33, 61 (September), 76 and 92.

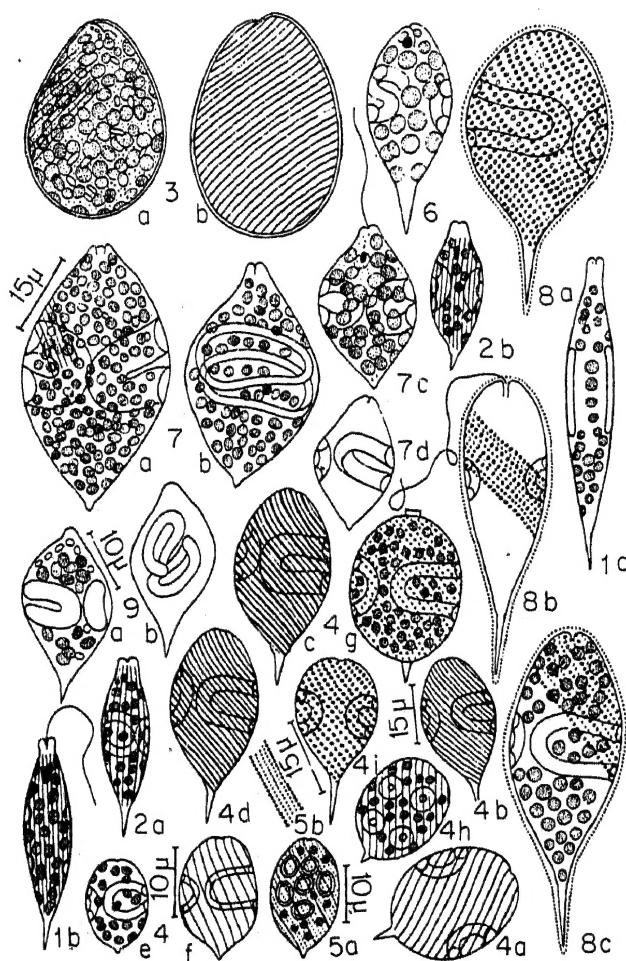
Range of measurements given by Conrad is  $22-30 \times 7.5-17 \mu\text{m}$ .

*Distribution in Indian region*: W. Bengal and Orissa (!).

var *suecica* Lemm. 1904 (figure 2b)

Lemmermann 1910, p. 506, figure 15 (p. 483); Conrad 1935, p. 18, figure 8.

Differs from the typical species in the basal part of the tail being swollen. Cell  $32 \times 12.8 \mu\text{m}$ ; tail alone  $3.5 \mu\text{m}$ .



Figures 1-9. 1a-b. *Lepocinclis marssonii* Lemm. emend. Conrad; 2a. *L. steinii* Lemm. emend. Conrad; 2b. *L. steinii* var *suecica* Lemm; 3a-b. *L. salina* Fritsch; 4a. *L. ovum* (Ehr) Lemm; 4b-d. *L. ovum* var *buetschlii* (Lemm) Conrad; 4e-f. *L. ovum* var *dimidio-minor* Defl.; 4g. *L. ovum* var *punctato-striata* Lemm; 4h. *L. ovum* var *discifera* Conrad; 4i. *L. ovum* var *verrucosum* Prowse; 5a-b. *L. lefevrei* var *cuttackensis* var nov (5b. diagrammatic showing striae); 6. *L. elongata* var *minor* var nov; 7a-b. *L. fusiformis* (Carter) Lemm. emend. Conrad; 7c-d. *L. fusiformis* fa *lemmermanni* Conrad; 8a-c. *L. spirogyra* Korsh.; 9a-b. *L. playfairiana* var *minor* var nov. [Same magnification: (1a-b; 2a-b; 3a-b; 4a, c-d, g, e; 6; 7a-d; 8a-c); (4b); (4f); (4i); (4h; 5a); (9a-c)].

*Habitat*: Stray in location 61 (N P 16-December).

Conrad gives dimensions of  $20-30 \times 9.5-15 \mu\text{m}$  and Lemmermann  $24.5-26 \times 9.5-12 \mu\text{m}$  for this variety.

*Distribution in Indian region*: Orissa (!).

### 3. *Lepocinclis salina* Fritsch 1914 (figures 3a-b)

Fritsch 1914, figures 3 A, B, E; Conrad 1935, pp. 57-59, figures 52-53; Hortobágyi 1969, p. 31, plate 4, figure 58.

Cell ellipsoid to ovoid with the posterior end broader and broadly rounded; anterior end also rounded with the pharyngeal cleft slightly towards one side; periplast fairly

thick and with spiral striae running from left to right; chromatophores numerous and discoid; paramylum also numerous, small and granular to rod-like and distributed in the cytoplasm; eye-spot a fairly large disc at the anterior end; flagellum not observed; cell  $30-45 \times 23-30.8 \mu\text{m}$ ; striae about 7 in  $10 \mu\text{m}$ .

*Habitat*: Abundant in location 127, common in locations 5a, 6, 29 (January) and 131; stray to rare in locations 17, 33 (March), 37, 43a, 50, 63 (N P 24, 25, 27, 29 August–November), 81, 85, 88a, 104, 105, 114–116, 118, 132, 133a and 157.

The organism agreed fairly well with the typical species but was slightly smaller, ( $36-60 \times 26-45 \mu\text{m}$ , Conrad), but was larger than var *minor* (Huber-Pest.) Conrad ( $34-37.5 \times 27-28 \mu\text{m}$  1935, p. 60). Unlike in var *minor* the emargination at the anterior end was regular as in the typical species. Hence it is kept under the typical species. Hortobágyi (1969) gives dimensions of  $41.6-45 \times 31.2-34 \mu\text{m}$  for his UP material.

It is not clear on what basis Kamat (1961–62, p. 20, figure 3) created a new variety, viz var *ahmedabadinensis* since it does not differ in any way from the typical species. The dimensions given ( $50-55 \times 35-38 \mu\text{m}$ ) fall within the limits of the typical species.

The organism resembles *L. texta* but differs chiefly in that the spiral striae in the latter run from right to left.

*Distribution in Indian region*: Gujarat (Kamat 1961–62 as *L. salina* var *ahmedabadinensis*); Maharashtra (Kamat 1963, also as the above variety); Uttar Pradesh (Hortobágyi 1969); Assam, W. Bengal, Bihar, Madhya Pradesh, Orissa, Andhra Pradesh, Karnataka and Tamilnadu (!).

#### 4. *Lepocinclis ovum* (Ehr) Lemm. 1901 (figure 4a)

Lemmermann 1910, pp. 504–05, figure 13 (p. 483); Conrad 1935, pp. 33–35, figure 25; as fa *typica* Huber-Pestalozzi 1955, p. 149.

Cell usually broadly ellipsoid to ovoid with pharyngeal opening exactly apical; posterior end continuing as a small tail of variable length; pellicle with spiral striae which are either uniform, or moderately or markedly thicker ones alternating with thinner ones; chromatophores small, numerous and discoid; paramylum two lateral rings; cells  $20-38 \times 13-23.5 \mu\text{m}$ ; tail up to  $7 \mu\text{m}$ .

*Habitat*: Stray to very rare in locations 5, 5a, 29, 45a, 57, 73, 76, 93, 103a, 118 and 136.

Kamat (1963, 1964) gives dimensions of  $25-38 \times 13-18 \mu\text{m}$ , and Suxena *et al* (1973)  $36-37 \times 27-28 \mu\text{m}$ . As stated by Conrad (1935), the shape of cell, nature of striae and length of tail were variable in the author's material also.

*Distribution in Indian region*: Maharashtra (Carter 1859; Gonzalves and Joshi 1946; Kamat 1963, 1964, 1968) Gujarat (Kamat 1961–62); Andhra Pradesh (Venkateswarlu 1976; 1981); Karnataka (Hosmani and Bharati 1975); Kerala (Suxena *et al* 1973); Himalayas (Subba Raju and Suxena 1979); Burma (Skuja 1949); Assam, W. Bengal, Orissa, Andhra Pradesh and Kerala (!).

#### var *buetschlii* (Lemm) Conrad 1935 (figures 4 b–d)

Conrad 1935, pp. 39–41, figure 31; Prowse 1958, p. 152, figure 2m; Hortobágyi 1969, p. 31, plate 4, figure 59; = *L. buetschlii* Lemm. 1901; 1913, p. 135, figure 224; Skuja

1949, p. 163; Gonzalves and Joshi 1946, p. 175, plate 5, figure 10; *non L. buetschlii* Lemm. in Drezepolski 1925, figure 139.

Cell elongate-ellipsoid; pellicle usually yellowish brown in colour with uniform, or moderately to markedly thickened striae alternating with thinner ones; tail with a characteristic basal swelling; cell  $38.7-42.2 \times 18.5-20.3 \mu\text{m}$ ; tail alone  $7-10.6 \mu\text{m}$ .

*Habitat*: Stray to very rare in locations 61 and 136a.

Conrad (1935) gives dimensions of  $30-42 \times 17-24 \mu\text{m}$ , Skuja (1949)  $40-44$  (including tail)  $\times 20-22 \mu\text{m}$ , and  $32-34 \mu\text{m}$  without tail, Prowse (1958)  $50$  (without tail)  $\times 23 \mu\text{m}$ , tail alone  $15 \mu\text{m}$ , and Hortobágyi (1969)  $45.5 \times 21.5 \mu\text{m}$ .

*Distribution in Indian region*: Maharashtra (Gonzalves and Joshi 1946); Uttar Pradesh (Hortobágyi 1969); Burma (Skuja 1949); Orissa and Kerala (!).

**var *dimidio-minor* Defl. 1924 (figures 4 e-f)**

Deflandre 1924, p. 1124, figures 25-28; Conrad 1935, pp. 42-43, figure 33.

Differs from the typical species in the cell being ellipsoid to subcylindrical with a shorter tail and the cell ( $17-19.5 \times 11-14 \mu\text{m}$ ) being much smaller.

*Habitat*: Stray in locations 23, 29 (December), 73 and 151 (November).

The variety agreed well with Deflandre's organism which measured  $14-24 \times 5-15 \mu\text{m}$ .

*Distribution in Indian region*: Gujarat (Kamat 1961-62, p. 20); Maharashtra (Kamat 1968, p. 98); Kerala (Suxena *et al* 1973, p. 334); W. Bengal, Orissa and Tamilnadu (!).

**var *punctato-striata* Lemm. 1905 (figure 4g)**

Lemmermann 1910, p. 505, figure 14 (p. 483); Conrad 1935, p. 45, figure 37; Skvortzov 1937, p. 71, plate 9, figure 5.

Differs from the typical species in the presence of a tube-like neck in the cell through which the flagellum emerges; striae punctate; cell  $28-35 \times 22-23 \mu\text{m}$  with the tail alone  $4.4-5.3 \mu\text{m}$ ; neck  $1.3 \times 1.3-1.5 \mu\text{m}$ .

*Habitat*: Common in location 136a.

The organism agreed with Lemmermann's variety in all respects except that it was slightly larger, the dimensions given by Lemmermann being  $27-28 \times 20-21 \mu\text{m}$  with tail  $3-7 \mu\text{m}$  long and neck  $1 \times 1.5 \mu\text{m}$ . Suxena (1955) has described a form of var *punctato-striata* from Andhra Pradesh ( $30.5 \times 24.5 \mu\text{m}$ ) in which there was only one apical knob instead of a collar or neck and the tail was in the form of an acute point. In the author's material the neck was sometimes not developed, but there was always a tail.

*Distribution in Indian region*: Burma (Skvortzov 1937); Andhra Pradesh (Suxena 1955); Kerala (!).

**var *discifera* Conrad 1935 (figure 4h)**

Conrad 1935, p. 47, figure 39.

Differs from the typical species in the paramylum being in the form of perforated discs and not in rings, and their number being more than two (usually 4–6); cell  $21 \times 14.3 \mu\text{m}$ , with tail  $1.8 \mu\text{m}$ ; tail in the form of a teat.

*Habitat*: Stray in location 92.

The organism from Kausalyagang (location 92) had slightly narrower cell and a slightly longer tail, Conrad's specimens measuring  $21\text{--}23 \times 16\text{--}17.5 \mu\text{m}$ .

*Distribution in Indian region*: Maharashtra (Kamat and Freitas 1976); Orissa (!).

**var *verrucosum* Prowse 1958 (figure 4i)**

Prowse 1958, pp. 154–55, figure 2s.

Cell oblong-ovoid with a sharp pointed tail; anterior end truncate-rounded; pellicle with spiral rows of fine verrucae running to the left; cell  $33 \times 15 \mu\text{m}$  with tail up to  $10 \mu\text{m}$ .

*Habitat*: Stray in locations 134 and 136a.

It agreed well with Prowse's variety measuring  $35 \times 17 \mu\text{m}$ .

*Distribution in Indian region*: Kerala and Karnataka (!).

**5. *Lepocinclis lefevrei* Conrad 1935**

Conrad 1935, pp. 64–65, figure 60.

Cell narrow-ovoid with the hind end slightly broader and with a stout obtuse to teat-like tail; pellicle with spiral striae which are beaded; alternate striae sometimes with stronger beading; paramylum as two lateral rings; chromatophores numerous, small and discoid; cell  $21\text{--}30 \times 12\text{--}17 \mu\text{m}$ . Known only from Belgium.

**var *cuttackensis* var nov. (figures 5a–b)**

Varietas a varietate typica differens ut 4–6 vel plura grana anuliformia paramyli et 2–3 striae parum piluiformes inter duas striae valde piluiforme habet; cellulae necnon paululo minores;  $20\text{--}30 \times 10.5\text{--}11.5 \mu\text{m}$ , cauda  $1.8\text{--}2.6 \mu\text{m}$ .

*Habitatio*: Rarissima in culturis luti tenuiter granulosi e loco N P 16 Jobra Cuttack dicto (loci 61) 23-9-1951.

Differs from the typical species in that there are 4–6 or more ring-like paramylum, with 2–3 weakly beaded striae between two strongly beaded ones; cell slightly smaller ( $20\text{--}23 \times 10.5\text{--}11.5 \mu\text{m}$ ), with a tail ( $1.8\text{--}2.6 \mu\text{m}$ ).

*Habitat*: In cultures of silt from location 61 (N P 16), very rare, 23 September 1951.

Though the organism shows some resemblance to *L. ovum* var *discifera* Conrad in



the number of paramylum and shape of cell, the paramylum are in rings and not perforated discs, the striae are beaded and the cell is narrower.

*Distribution in Indian region:* Orissa (!).

#### 6. *Lepocinclis elongata* (Swirenko) Conrad 1935

Conrad 1935, p. 64, figure 59; = *L. fusiformis* var *elongata* Swirenko 1928.

Cell fusiform with the anterior cleft slightly towards one side; posterior end prolonged into a conical tail; pellicle with spiral striae; paramylum as two rings; cell 52–54  $\times$  23  $\mu$ m. This species is known only from Russia.

##### var *minor* var *nov.* (figure 6)

Cellulae minores quam forma typica; tantummodo 32.5  $\mu$ m longitudine (cum cauda) atque 17.5  $\mu$ m latitudine, cauda 10  $\mu$ m; chromatophora satis magna, discoidea, numerosaque; stigma prope extremitatem anteriorem; striae non observatae.

*Habitatio:* Aberrans in loco Sagore Dutt Pond-2, Kamarhati, W. Bengal dicto (loc. 27a) 30-5-1950.

##### var *minor* var *nov.* (figure 6)

Cell smaller than in the typical species, (32.5  $\mu$ m in length, including tail; 17.5  $\mu$ m in breadth, with tail 10  $\mu$ m); chromatophores fairly large, discoid and numerous; eye-spot near anterior end; striae not observed.

*Habitat:* Stray in location 27a, 30-5-1950.

*Distribution in Indian region:* W. Bengal (!).

#### 7. *Lepocinclis fusiformis* (Carter) Lemm. emend. Conrad 1935 (figures 7a–b)

Conrad 1935, pp. 49–51, figures 42–44; Prowse 1962, p. 111, plate 1, figure 1; = *Euglena fusiformis* Carter 1859, p. 17, plate 1, figures 15, 17; = *L. fusiformis* (Carter) Lemm. 1901; 1910, p. 507, figure 22 (p. 483).

Cell short and broadly ellipsoid to spindle-shaped with both ends obtuse, the very hind end being in the form of a teat and the front end with a marked indentation or cleft; pellicle firm and usually thick with spiral striae; chromatophores small, numerous and discoid; paramylum two large rings, one on each side or sometimes appearing one above the other; eye-spot and flagellum not observed; cell 38–52.6  $\times$  27–31  $\mu$ m; tail alone 1.8  $\mu$ m long.

*Habitat:* Common in location 29 (February) and 93 (N P 5) and stray to rare in locations 2, 29 (June), 61, 136a and 137a.

The organism agreed fairly well with the ones described by previous workers (25–51–60  $\times$  12–39  $\mu$ m) but the chromatophores were smaller as shown in

Lemmermann's figure. Conrad (1935, figure 44) states that the organism sometimes occurs in a palmelloid condition with copious mucilage, when the periplast is usually thin.

*Distribution in Indian region:* Maharashtra (Carter 1859); Burma (Skvortzov 1937); Kerala (Suxena *et al* 1973); Assam, W. Bengal, Orissa and Kerala (!).

**fa *lemmermannii* Conrad 1935 (figures 7c-d)**

Conrad 1935, p. 52, figure 45; = *L. globosa* Francé var *fusiformis* Lemm. 1901; 1910, p. 508

Cell smaller than in the typical species and somewhat rhomboidal; flagellum nearly body length; eye-spot at anterior end; cell  $25.5-30 \times 13.8-15.8-18.9 \mu\text{m}$ .

*Habitat:* Stray to rare in locations 23, 29 (December), 63 (N P 31, March), 151 (February) and 152a.

The dimensions were slightly larger than those given by Conrad ( $14-21 \times 8-11 \mu\text{m}$ ). The Indian organism actually comes midway between the typical species and fa *lemmermannii*, but nearer the latter.

*Distribution in Indian region:* W. Bengal, Orissa and Tamilnadu (!).

**8. *Lepocinclis spirogyra* Korshikov 1942 (figures 8a-c)**

Korshikov 1942, pp. 25-26, figure 3.

Cell fusiform with variable thickness and enclosed within a mucilaginous envelope; anterior end broadly rounded; posterior end produced into a distinct spine; periplast with spiral rows of brown, more or less rectangular, verrucae running from right to left and making one turn round the body; beading with uniformly thick verrucae or alternate rows showing weak beading; chromatophores discoid and numerous; paramylum two large median lateral rings; flagellum when observed about  $2/3$  body length; cell  $55-61 \times 17.5-30 \mu\text{m}$ , with tail alone  $10.5-14.5 \mu\text{m}$ .

*Habitat:* Rare to common in locations 136 and 136a; stray in locations 63, 73, 76 and 92.

The organism agreed fairly well with Korshikov's species except that the rows of verrucae were sometimes not uniform, alternate rows showing weaker beading which was not observed in Korshikov's material. Also, the range of breadth in the Indian material was greater, Korshikov's organism measuring  $53-68 \times 16.5-20 \mu\text{m}$ . The mucilaginous sheath in the Indian material was close fitting compared to the thicker layer in the Russian material. This could, however, be due to the fact that the Indian specimen was examined only after preservation. Korshikov also stated that the flagellum when observed was very short (only about  $1/5$  body length as shown in his figure) whereas in the Indian material it was nearly  $2/3$  body length in one individual in which it was observed.

*Distribution in Indian region:* Kerala and Orissa (!).

### 9. *Lepocinclis playfairiana* (Defl) Defl 1932

Conrad 1935, pp. 67–68, figure 65; Hortobágyi 1943, p. 87, figures 22–23; = *L. fusiformis* var *caudata* Playfair 1921, p. 127, figures 3 j-k; = *Crumenula playfairiana* Defl 1929.

Cell more or less fusiform with a slight depression on one side at the anterior end thereby forming a beak at the tip; posterior end continuing as a fairly long tail which is usually bent slightly towards one side; chromatophores numerous and discoid; paramylum two large rings, with additional small rods or granules; periplast smooth and without striae; cell (including tail)  $35.6\text{--}40\text{--}50 \times 17\text{--}28 \mu\text{m}$ ; tail  $10\text{--}16 \times 4 \mu\text{m}$ . Known only from Australia, France and Hungary.

#### var *minor* var *nov.* (figures 9a–b)

Varietas a varietate typica differens ut minor, cellulis tantummode  $28\text{--}30 \mu\text{m}$  (cum cauda)  $\times 13.7\text{--}14.7 \mu\text{m}$ ; cauda sola  $3.7\text{--}4.5 \mu\text{m}$ .

*Habitatio*: Rara in stagno, in loco Chetput Fish Farm, Madras dicto (loc. 154) 27-4-1943 et Vellore (loc. 159) 19-12-1954.

Differs from the typical species in its smaller size, the cell measuring only  $28\text{--}30 \mu\text{m}$  (including tail)  $\times 13.7\text{--}14.7 \mu\text{m}$ , with tail alone  $3.7\text{--}4.5 \mu\text{m}$ .

*Habitat*: Rare in locations 154 (27 April 1943) and 159, (19 December 1954).

*Distribution in Indian region*: Tamilnadu (!).

Other taxa of *Lepocinclis* reported from the Indian region are:

*L. acuta* Prescott, from Maharashtra (Ashtekar 1932)

*L. glabra* Drez. f. *minor* Prescott, from Maharashtra (Kamat 1975)

*L. marssonii* Lemm. emend. Conrad (1935) var *khannae* (Skvortzov) Huber-Pest. (1955) from Burma (as *L. khannae* Skvortzov 1937)

*L. ovata* (Playf) Conrad var *deflandriana* Conrad (1935) from Kerala (Suxena et al 1973)

*L. ovum* (Ehr) Lemm var *indica* (Skvortzov) Huber-Pest. (1955). As *L. indica* Skvortz., from Burma (Skvortzov 1937) and from Andhra Pradesh (Suxena 1955).

*L. ovum* var *angustata* (Defl) Conrad (1935)—as *L. ovum* var *angustata* Defl, from Bombay (Gonzalves and Joshi 1946).

As already stated, *L. texta* Lemm. emend. Conrad (1935) reported by Carter (1856a) from Bombay, and Kamat and Freitas (1976) from Nagpur has been treated as *Euglena texta* (Duj) Huebner (1886) by Philipose (1982).

### B. Genus *Phacus* Dujardin 1841

Single-celled, free swimming with constant shape, usually flattened, rarely otherwise. Periplast firm and rigid with margins smooth or sometimes constricted, with longitudinal or spiral striae, rarely smooth, or with fine spines, warts or punctae or sometimes with these instead of striae. Hind end of cell rounded or with a tail of varying length. Cell frequently with a crest or an apical furrow of varying length. Vacuolar

system as in *Euglena*. A single flagellum which is usually longer than the body. Eye-spot near the reservoir. Chromatophores numerous, parietal and usually discoid or irregularly polygonal and without pyrenoids. Paramylum numerous and of different shapes and size. Nucleus usually central. Mostly in freshwater.

*Key to the taxa described*

Subgenus *Chlorophacus* Pochmann 1942 (with chromatophores and green in colour)

- I. Cell mostly flattened like a lens or in optical cross-section three-edged; frequently with basal, lateral or dorsal thickening; pellicular striae longitudinal or spiral; paramylum central or lateral, discoid, ring-like or watch-glass like, rarely rod-like; cells 12–200  $\mu\text{m}$  in size..... Section *Proterophacus* Pochmann 1942
  - (A) Cell without a tail; hind end entire or nearly so; round to elongate in outline, flat in optical cross-section.
    - (a) Cell nearly round
      - (i) With a disc-like paramylum; cell (40–) 46–48 (–55)  $\times$  39–41.6 (–49)  $\mu\text{m}$ ..... 1. *P. stokesi*
      - (ii) With a pseudo-ring like paramylum; cell margin irregularly undulate; 35.5–37  $\times$  30.5–33.3  $\mu\text{m}$ ..... 2. *P. balatonicus*  
Cell larger, 48.4  $\times$  41  $\mu\text{m}$ ..... var *major* var *nov*
      - (iii) With a number of medium-sized paramylum; number of paramylum and striae variable; cell 48–58  $\times$  40–48  $\mu\text{m}$ ..... 3. *P. lefevrei*
    - (b) Cell more or less oval
      - (i) Breadth of cell about 3/5 of length; paramylum single; cell 14–14.5 (–15.7)  $\times$  (7.5–) 8 (–9)  $\mu\text{m}$ ..... 4. *P. nannos*
      - (ii) Cell nearly two times as long as broad
        - (1) Paramylum usually two and disc-like; cell 17–18 (–19.8)  $\times$  7.9–8.5  $\mu\text{m}$ ..... 5. *P. wettsteinii*
        - (2) Paramylum usually one and ring-like; cell slightly broader towards hind end, 18–20 (–22)  $\times$  (6–) 7–9 (–11)  $\mu\text{m}$ ..... 6. *P. pusillus*
  - (B) Posterior end of cell with a blunt knob; pellicular striae spiral; paramylum lateral, large and shell-like; cell 12.5–17 (–17.6)  $\times$  8–13  $\mu\text{m}$ ..... 7. *P. agilis*
  - (C) Cell with hind end cuneiform (wedge-like) and sometimes with a short straight or slightly oblique tail; usually 3–5 edged
    - (a) Cell symmetrical  
Paramylum 1–2 small rings or several discs; cell (18–) 22–30  $\times$  (13–) 17–27  $\mu\text{m}$ ..... 8. *P. acuminatus*  
Cell with 4–5 edges and a short tail; paramylum three, two unequal rings and a disc; cell 31.5  $\times$  27  $\mu\text{m}$ ..... var *barrackporensis* var *nov*
    - (b) Cell somewhat asymmetrical, or symmetrical with the tail at an angle to the long axis; cell ellipsoid, 24–33 (–35)  $\times$  15–22 (–26)  $\mu\text{m}$ . 9. *P. brachykentron*
  - (D) Hind end of cell somewhat conical and with a short tail.  
Cell strongly twisted with the dorsal side curved inwards, (18.5–) 24–31  $\times$  (5.3–) 7–11 (–13.2)  $\mu\text{m}$ ..... 10. *P. inflexus*
  - (E) Cell usually thickened on one or both flanks and often with a broad furrow in between; paramylum two lateral discs or rings
    - (a) Cell nearly as broad as long; tail short and oblique or slightly twisted.
      - (i) Pellicular striae more or less straight; cell (17–) 20–35 (–37.7)  $\times$  (17–) 18–26 (–29.3)  $\mu\text{m}$ ; tail up to 5  $\mu\text{m}$ ..... 11. *P. curvicauda*

- (ii) Striae nearly vertical on one side and spiral on the other side; cell  $26-30 \times 22-23.5 \mu\text{m}$  ..... 12. *P. textus*
- (b) Cell in two diagonal halves and usually longer than broad; with a short oblique to curved tail; cell  $23-27 (-40) \times (16.8-) 26-27 (-30) \mu\text{m}$  ..... 13. *P. anomalus*
- (F) Cell bent, twisted or asymmetrically inflated
  - (a) Cell bent at an angle; dorsal side with a keel, ventral side with a furrow; paramylum usually two; cell  $(27-)35 (-45) \times (8-) 10-12 (-19) \mu\text{m}$  ..... 14. *P. raciborskii*
  - (b) Cell strongly twisted
    - (i) With one twist; cell triangular in outline with a perforated disc-like paramylum at each angle; tail short and like a teat; cell  $35-37 \times 30-32 \mu\text{m}$  ..... 15. *P. mammillatus* sp. nov
    - (ii) In two twisted halves separated by two furrows; paramylum two lateral irregular discs; cell  $(34-) 40-48 \times 24-32 \mu\text{m}$  ..... 16. *P. contortus*
  - (c) Cell with two unequal asymmetrical halves with one lobe shorter and broader; longer lobe with a tail and one large central paramylum; cell  $25-32 \times 22-23 \mu\text{m}$ ; tail  $4-6 \mu\text{m}$  ..... 17. *P. inflatus*  
Inflation less than in type; cell larger with closer striae; tail often bent; paramylum 2-3 medium-sized discs and additional smaller ones; cell  $47-55 \times (28-)30-33 \mu\text{m}$ ; tail  $7.5-9.4 \mu\text{m}$  ..... var *pterophorus*
- (G) Cell with well developed, straight, oblique or curved tail
  - (a) Tail oblique, paramylum one or two; cell margins entire
    - (i) Paramylum two central concentric ones of unequal size; cell nearly round or slightly longer than broad and slightly asymmetrical; cell  $(31-) 40-80 \times (20-) 30-50 \mu\text{m}$ ; tail  $5-10 \mu\text{m}$  ..... 18. *P. pleuronectes*
    - (ii) Paramylum a single large central disc; cell broadly oval;  $(43-) 46-56 \times (29-) 30-32 \mu\text{m}$ ; tail  $9-15 \mu\text{m}$  ..... 19. *P. platealea*
  - (b) Tail curved; paramylum two discs; cell margins entire
    - (i) Cell narrowed at both ends, elongated and slightly asymmetrical; tail hook-like; cell  $(25-) 37-55 \times 20-35 \mu\text{m}$  ..... 20. *P. hamatus*
    - (ii) Cell nearly round or slightly longer than broad, 3-edged in optical cross-section; with a large central and a smaller excentric paramylum; cell  $(35-) 50-100 \times (28-) 30-60 \mu\text{m}$  ..... 21. *P. orbicularis*
    - (iii) Cell sharply keeled and angular with an oblique to curved tail; paramylum 1-2 discs; cell  $(34-) 38-44 \times (24-) 25-32 \mu\text{m}$  ..... 22. *P. carinatus*
  - (c) Tail more or less straight or slightly curved; cell margins entire or irregularly crenate to undulate.
    - (i) Paramylum usually two, unequal and arranged along the long axis with smaller one at hind end; cell with a dorsal keel or pad
      - (1) Flanks of cell entire; cell elongate and keeled with hind end drawn out into a nearly straight tail;  $20-30-34-50 \times 10-15-25- (31.5) \mu\text{m}$ ; tail up to  $8 \mu\text{m}$  ..... 23. *P. caudatus*  
Cell larger,  $74 \times 35 \mu\text{m}$  with tail about  $9 \mu\text{m}$  ..... var *major* var *nov*
      - (2) Flanks of cell entire or irregularly crenate; cell triquetrate; tail straight or slightly bent
    - (+) Anterior paramylum of moderate size; cell  $35-41 \times 17-20 \mu\text{m}$  .... 24. *P. ankylonoton*



- (+ +) Anterior paramylum very large and nearly filling cell; cell  $33-40 \times 20$  ( $-22.5$ )  $\mu\text{m}$ .....24A. *P. formosus*
- (3) Flanks of cell entire; cell nearly rectangular; paramylum a large disc besides smaller ones; tail straight; cell  $28-33 \times 13-20$   $\mu\text{m}$  24B. *P. obolus*
- (ii) Paramylum a single central ring; cell flat with flanks irregularly crenate to undulate; cell without a dorsal keel; tail slightly bent; cell  $50-80 \times 30-48$   $\mu\text{m}$ .....25. *P. undulatus*
- (iii) Paramylum usually a large central disc; one or both margins with a single constriction; tail curved; cell (including tail)  $30-42 \times 22-35$   $\mu\text{m}$ . 25A. *P. onyx*
- (H) Cell with a medium-sized wedge-shaped tail.  
Paramylum ring-like or ring- and disc-like; Cell about  $2\frac{1}{2}$  times as long as broad with tail  $\frac{1}{4}-\frac{1}{3}$  body length; cell  $86-105$  ( $-130$ )  $\times 25-50$  ( $-55$ )  $\mu\text{m}$ ; tail alone  $23-30$   $\mu\text{m}$ .....26. *P. meson*
- (I) Cell long and thin with a tail as long as the body or shorter or longer.
- (a) Cell usually flat or slightly twisted at anterior end only
- (i) Tail usually irregularly twisted or bent at end, about half body length and at an angle to hind end of cell; paramylum 3, rarely more; cell (excluding tail) up to  $80$   $\mu\text{m}$ ,  $37-55$   $\mu\text{m}$  broad, tail  $37-55$   $\mu\text{m}$ ..... 27. *P. ranula*
- (1) Tail shorter and nearly straight; paramylum more than two discs or rings; cell (excluding tail)  $74-83 \times 38.4-47.5$   $\mu\text{m}$ , tail  $24.5-33$   $\mu\text{m}$  ..... var *brevicaudatus* var *nov*
- (2) Tail recurved; with 2 large central paramylum appearing like a biconvex lens and additional discoid ones; cell ( $40.5-$ )  $47-50 \times (27.3-)$   $33-34$   $\mu\text{m}$ , tail  $33-35$   $\mu\text{m}$ ..... var *africana*
- (ii) Tail not twisted and about body length; paramylum usually one, rarely two concentric discs.
- (1) Cell heart-shaped, lateral margins usually entire, paramylum ring-like; cell ( $74-$ )  $85-190 \times (27.5-)$   $40-70$  ( $-75$ )  $\mu\text{m}$ .....28. *P. longicauda*
- (+) Cell elongate-elliptic,  $100-150-170 \times 35-50$   $\mu\text{m}$ ; paramylum disc-like or ring-like ..... var. *rotunda*
- (+ +) Cell oval, ( $146-$ )  $170-188 \times 40-65$   $\mu\text{m}$ ; tail up to  $100$   $\mu\text{m}$ ; paramylum ring-like ..... var *major*
- (+ + +) Cell club-shaped or with hind end narrower and asymmetrical,  $110-120 \times 41-44$   $\mu\text{m}$ ; paramylum a central disc ..... var *attenuata*
- (2) Lateral margins of cell with a notch; paramylum ring-like; cell  $80-130 \times 35-44$  ( $-47.5$ )  $\mu\text{m}$  ..... var *insecta*
- (b) Cell strongly bent or twisted
- (i) Cell bent
- (1) Cell bent like a saddle with under side twisted and pear-shaped,  $60-75 \times 31-41$   $\mu\text{m}$ ; tail about half body length and slightly curved ..... 29. *P. ephippion*
- (2) Cell strongly bent on one side with a beak at front end and asymmetrical,  $73-90 \times 30-45$   $\mu\text{m}$ ; tail about  $\frac{3}{4}$  body length and straight ..... 30. *P. circumflexus*
- (ii) Cell strongly twisted
- (1) Cell spirally twisted once with cell halves nearly bilaterally symmetrical; paramylum ring-like; cell (excluding tail) ( $64-$ )  $80-112 \times 25-38-52$   $\mu\text{m}$  ..... 31. *P. tortus*

- (2) Cell with  $1\frac{1}{2}$  twists and only one ridge; paramylum ring-like; cell (excluding tail)  $62-90 \times 40-54 \mu\text{m}$ ..... 31A. *P. sesquitortus*
- (3) Cell twisted like a snail shell with a dorsal and ventral wing; paramylum a central disc; cell  $70-120 \times 30-54 \mu\text{m}$ ..... 32. *P. helikoides*
- II. Cell pear- or spindle-shaped and thick, sometimes triangular or slightly twisted; pellicle composed by thick ridges; paramylum one or two and lateral or dorsio-ventral; chromatophores usually numerous, small and discoid, rarely two and lateral ..... Section *Pleurapsis* Pochmann 1942
- Cell with many small chromatophores, ribs running towards left and without crests.
- (a) Tail shorter than body, straight or slightly curved; cell pear-shaped and slightly longer than broad,  $30-55 \times 15-21 \mu\text{m}$  ..... 33. *P. pyrum*
- (b) Tail a prolongation of the body; cell spindle-shaped, much longer than broad and 3-edged in optical cross-section,  $28-30 \times 9-10 \mu\text{m}$  .... 34. *P. atrakoides*
- III. Cell usually flattened like a lens; pellicle smooth or with longitudinal striae which are punctate or with crests; paramylum two lateral pads ..... Section *Acanthopeltis* Pochmann 1942
- (A) Cell wall smooth or with rows of fine punctae; cell  $26-27 \times 14.5-19 \mu\text{m}$ ..... 35. *P. glaber*
- (B) Cell wall with cone-like warts  
Warts arranged in longitudinal rows  
Cell longer than broad, breadth  $2/3-3/5$  times length,  $25-36 \times 15-23 \mu\text{m}$  and  $6-11 \mu\text{m}$  thick ..... 36. *P. suecicus*
- (C) Pellicle with longitudinal rows of small spines.  
Spines pointed towards the apex; cell  $30-40-55 \times 18-33 \mu\text{m}$ ... 37. *P. hispidulus*
- Sections *Kampyloter* Pochmann 1942 and *Dolichoplastes* Huber-Pestalozzi 1955 with one species each, and Subgenus *Hyalophacus* Pochmann (1942) (without plastids) with one species, not reported from the Indian region so far.

## Section I. *Proterophacus* Pochmann 1942

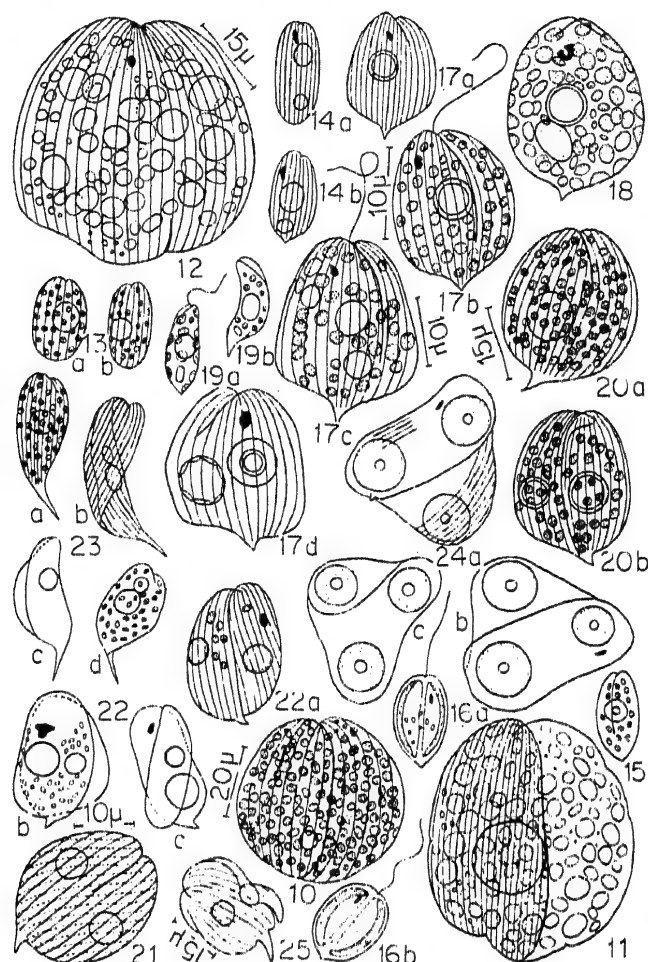
### 1. *Phacus stokesi* Lemm. 1910 (figure 10)

Lemmermann 1910, p. 518, figure 9 (p. 483); Huber-Pestalozzi 1955, pp. 180-81, figures 194; Suxena *et al* 1973, p. 335, figures 92 a-b.

Cell broadly oval to nearly circular; apical groove reaching almost the hind end; pellicular striae longitudinal; chromatophores small, numerous and discoid; paramylum a small or large disc nearer the hind end; cell  $46-49 \times 42-49 \mu\text{m}$ .

*Habitat*: Stray in locations 33 (April), 76, 111a, 112b and 136a.

According to Huber-Pestalozzi (1955), since Stokes' original species (*Cyclanura orbiculata*) ( $46 \mu\text{m}$ ), Allerge and Jahn's organism ( $46 \times 40 \mu\text{m}$ ) and Huber-Pestalozzi's material ( $40-48 \times 39-41.6 \mu\text{m}$ ) were all larger than given by Pochmann (1942) for the typical species ( $13-20 \times 12-15 \mu\text{m}$ ) including f. *minor* Conrad 1938 ( $13-16 \times 12-13 \mu\text{m}$ ), the larger one will have to remain as the typical species and the smaller one as f. *minor* Conrad. Prowse's Malaysian species (Prowse 1958) also measures  $45-55$



Figures 10–25. 10. *Phacus stokesi* Lemm.; 11. *P. balatonicus* var *major* var *nov* (striae shown only in one half of cell); 12. *P. lefevrei* Bourr.; 13a–b. *P. nannos* Pochm.; 14a–b. *P. wettsteinii* Drez.; 15. *P. pusillus* Lemm.; 16a–b. *P. agilis* Skuja; 17a–c. *P. acuminatus* (Stokes) Huber-Pest.; 17d. *P. acuminatus* var *barrackporensis* var *nov*; 18. *P. brachykentron* Pochm. (striae not shown); 19a–b. *P. inflexus* (Kissel.) Pochm.; 20a–b. *P. curvicauda* Swir.; 21. *P. textus* Pochm.; 22a–c. *P. anomalus* Fritsch et Rich.; 23a–d. *P. raciborskii* Drez.; 24a–c. *P. mammillatus* sp. *nov* (three views of same individual); 25. *P. contortus* Bourr. [Same magnification: (10); (11; 12; 13a–b; 14a–b; 16a–b; 17a, d; 18; 19a–b; 22a–c; 23a–d; 24a–c); (17c); (20); (21); (25)].

× 40–48  $\mu\text{m}$ . Hortobágyi's (1943) species ( $16.4 \times 17 \mu\text{m}$ ) thus belongs to f. *minor*. Naidu (1966, figure 19) gives dimensions of  $31\text{--}33 \times 24\text{--}25 \mu\text{m}$  for his Vijayawada material. However, his figure looks more like that of *P. brevicaudatus* (Klebs) Lemm. 1910. The paramylum is also shown as a ring. This species (see Pochmann 1942, figure 3) measures  $25\text{--}35 \times 20\text{--}25 \mu\text{m}$ . Suxena *et al*'s material from Kerala measured  $44\text{--}45 \times 41\text{--}42 \mu\text{m}$  with thickness 9–11  $\mu\text{m}$ .

*Distribution in Indian region:* Kerala (Suxena *et al* 1973); Maharashtra (Ashtekar 1982); Kerala, Andhra Pradesh, Orissa and W. Bengal (!).

## 2. *Phacus balatonicus* Hortobágyi 1943

Hortobágyi 1943, pp. 87–88, figures 27–36; Huber-Pestalozzi 1955, p. 181, figure 194A.

Cell broadly oval to egg-shaped and sometimes with irregularly undulate sides; both ends broadly rounded; apical furrow reaching the hind end; periplast with fairly close longitudinal striae; chromatophores numerous and disc-shaped; paramylum in the form of a "pseudo-ring" (thick in the periphery and thin towards the middle) near the apex or towards the side of the cell; additional watch-glass like paramylum also present; cell  $35.5\text{--}37 \times 30.5\text{--}33 \mu\text{m}$ .

Reported so far only from Hungary.

### *var major* var nov (figure 11)

Varietas a varietate typica et a var *boglariense* Hortob. (Hortobágyi 1943, figures 40–42) differens ut paululo maior; grana paramyli aliquantulum unum latus versus, et propius extremitatem posteriorem sita; cellula  $48.4 \times 41 \mu\text{m}$ .

*Habitatio*: Aberrans in loco Thandankulam, Azhicode, Trichur dicto (loc. 136a) 26-2-1949.

Differs from the typical species and var *boglariensis* Hortob. ( $36.7\text{--}39 \times 27\text{--}29.6 \mu\text{m}$ ) (Hortobágyi 1943, figures 40–42) in its slightly larger size; paramylum slightly towards one side; nearer the hind end; cell  $48.4 \times 41 \mu\text{m}$ .

*Habitat*: Stray in location 136a.

*Distribution in Indian region*: Kerala (!).

## 3. *Phacus lefevrei* Bourrelly in Bourrelly et Manguin 1952 (figures 12, 12a)

Huber-Pestalozzi 1955, pp. 182–83, figure 196B; Prowse 1958, p. 160, figure 4m; Bourrelly 1961, p. 305, Plate 4, figure 13.

Cell broadly ellipsoid with both ends rounded; posterior end broader with a fairly large swelling; anterior end with a small depression; furrow extending from front to hind end; periplast with wide longitudinal striae; paramylum numerous (about 25–30), sub-spherical or discoid and usually of medium size; eye-spot small; cell  $48.5\text{--}49 \times 43\text{--}47.5 \mu\text{m}$ .

*Habitat*: Rare in locations 10, 26a and 64.

The species agreed in most respects with Bourrelly's organisms from Guadeloupe ( $48\text{--}50 \times 40\text{--}45 \mu\text{m}$ ) and Ivory Coast ( $58 \times 48 \mu\text{m}$ ). However, the number of paramylum in the present specimen was larger (about 25–30) compared to about 14–19 figured by Bourrelly and the hollowed centre reported by Bourrelly in some of the paramylum was not observed. Bourrelly also stated that the striae were fewer (9, as seen in his figure) and the paramylum more in number (19) in the Ivory Coast material than in the Guadeloupe specimen. He did not observe an eye-spot. Prowse (1958) showed eight hollowed paramylum, eleven striae and a large eyespot in his Malaysian specimen measuring  $58 \times 46 \mu\text{m}$ . In a specimen from location 10 examined by the author, the cell

measured  $49 \times 43 \mu\text{m}$ , had 15 striae and 25 paramylum mostly of medium size and in another specimen from location 26a the cell measured  $48.5 \times 47.5 \mu\text{m}$ , there were about thirty paramylum of various sizes and twenty-one striae. The latter had also a small eye-spot. However, the Indian specimens did not differ materially from Bourrelly's species and is, therefore, retained under it.

This species resembles *Phacus segreti* Allorge *et* Lefèvre (see Pochmann 1942, figure 4) in general shape, but the latter differs in having only two large paramylum discs and the striae are sometimes slightly spiral.

*Distribution in Indian region:* Assam, W. Bengal and Orissa (!).

#### 4. *Phacus nannos* Pochmann 1942 (figures 13a–b)

Pochmann 1942, p. 123, figure 5.

Cell elongate with broadly rounded ends and without any acute point at the hind end; pellicular striae longitudinal; chromatophores small, numerous and discoid; paramylum one large circular disc; cell  $15.7 \times 7.5\text{--}9 \mu\text{m}$ .

*Habitat:* Stray in location 23.

The organism agreed fairly well with Pochmann's species ( $14\text{--}14.7 \times 8 \mu\text{m}$ ). *P. nannos* differs from *P. wettsteinii* Drez. (see below) in its smaller size and the hind end being always rounded.

*Distribution in Indian region:* W. Bengal (!).

#### 5. *Phacus wettsteinii* Drezepolski 1925 (figures 14a–b)

Drezepolski 1925, p. 267, Tafel 3, figure 122; Pochmann 1942, pp. 123–24, figure 6.

Cell elongate-oval with both ends rounded or with a sharp point at the hind end; apical groove reaching up to the hind end; pellicle hyaline and with longitudinal striae; paramylum usually two rounded discs; cell  $17.8\text{--}19.8 \times 7.9\text{--}8.5 \mu\text{m}$ .

*Habitat:* Stray in location 29 (January).

The organism agreed fairly well with the European and Malaysian (see Prowse 1958, figure 3a) ones but the paramylum was sometimes slightly elongate as in the Malaysian one.

*Distribution in Indian region:* W. Bengal (!).

#### 6. *Phacus pusillus* Lemm. 1910 (figure 15)

Lemmermann 1910, p. 514; 1913, p. 141, figure 223; Pochmann 1942, pp. 124–25, figure 7; Suxena 1955, p. 435, figures 30–33; Hortobágyi 1969, p. 32, plate 5, figure 63.

Cell elongated with wing-like thickening on either side and a wide groove along the full length of the cell; both ends broadly rounded with a pointed tip at hind end; pellicular



striae spiral to nearly longitudinal; paramylum 1-2 and ring-like; cell  $17.5-18.5 \times 8 \mu\text{m}$ .

*Habitat*: Stray in locations 28 (April), 29 (April), 33 (April, July and September), 134 and 154.

*Distribution in Indian region*: Andhra Pradesh (Suxena 1955; Naidu 1966); Uttar Pradesh (Hortobágyi 1969); Maharashtra (Ashtekar 1982); W. Bengal, Karnataka and Tamilnadu (!).

#### 7. *Phacus agilis* Skuja 1926 (figures 16a-b)

Conrad 1938, p. 7, figures 18-22; Pochmann 1942, pp. 134-35, figure 21; Huber-Pestalozzi 1955, p. 189, figure 215.

Cell-shaped like a coffee bean and elongate-ellipsoid to nearly four-cornered; anterior end slightly narrowed; posterior end also narrowed and obtuse with a knob-like tail in line with the longitudinal axis; pellicle with fine slightly spiral striae; flagellum about body length; paramylum two, lateral and like the shell of a mussel; cell  $15.8-17.6 \times 9.7-11.4 \mu\text{m}$ .

*Habitat*: Stray in location 21 (November), rare in location 33 (July).

*Distribution in Indian region*: Andhra Pradesh (Seenayya 1972); Gujarat (Patel and Waghodekar 1981); W. Bengal (!).

#### 8. *Phacus acuminatus* (Stokes) Huber-Pest. 1955 (figures 17a-c)

Huber-Pestalozzi 1955, p. 192, figure 224; = *P. acuminata* Stokes 1885; Lemmermann 1913, pp. 138-39, figure 233; Skuja 1949, p. 163; = *P. acuminatus* subsp. *americana* Pochmann 1942, p. 141, figures 32 a-c.

Cell broadly oval to triangular or nearly spherical with the anterior end slightly narrowed and rounded; posterior end broader and ending in a short sharp point or conical tail; apical groove usually reaching up to the hind end; pellicular striae longitudinal; chromatophores small, numerous and discoid; paramylum one to two small roundish rings and/or several (2-4) discs of variable size distributed irregularly inside the cell; flagellum about body length or slightly shorter; eye-spot small; cell  $18-28 \times 13-22 \mu\text{m}$ ; tail  $1.3-3.5 \mu\text{m}$ .

*Habitat*: Stray to very rare in locations 1, 2, 29, 32, 33 (April), 33a, 37, 63 (July), 73, 92, 102, 131a, 136a and 151 (April, September-October).

*Distribution in Indian region*: Burma (Skuja 1949); Maharashtra (Kamat 1963, 1968; Ashtekar 1982); Gujarat (Patel and Waghodekar 1981); Rajasthan (Trivedy 1982), Kerala (Suxena *et al* 1973); Assam, W. Bengal, Bihar, Orissa, Andhra Pradesh, Karnataka, Kerala and Tamilnadu (!).

Suxena *et al* (1973), Ashtekar (1982) and Trivedy (1982) give the specific name as *P. acuminatus* Stokes while Patel and Waghodekar (1981) give it as *P. acuminatus* var *americana* Pochm.

**var *barrackporensis* var nov. (figure 17d)**

Cellula late ovalis et apululum asymmetrica, plana et 4–5 angulata, sulco apicali solum usque ad circa tertiam partem longitudinis corporis; striae pelliculatae prominentes; grana paramyli tria, duo anuliformia inaequaliaque, tertium discoideum; stigma satis magnum; extremitas posterior caudam brevem obtusamque quae angulum parvum centra axem longitudinem format habens; cellula  $31.5 \times 27 \mu\text{m}$ , cauda sola *c.*  $3 \mu\text{m}$ .

*Habitatio*: Aberrans in cisterna stationis pro investigatione, Barrackpore (loc. 29) 30-11-1949.

Cell broadly oval and slightly asymmetrical, flat and 4–5 angled, with the apical groove only up to about one-third the body length; pellicular striae prominent; paramylum three, two ring-like and unequal, the third disc-like; eye-spot fairly large; posterior end with a short obtuse tail which is at a slight angle to the longitudinal axis; cell  $31.5 \times 27 \mu\text{m}$  with tail alone about  $3 \mu\text{m}$ .

*Habitat*: Stray in location 29 (November).

Though the organism resembles *P. acuminatus* var *indica* (Pochm) Huber-Pestalozzi (1955, figure 229) in its shape, the tail is shorter and not so sharply pointed, the apical furrow does not extend to the posterior end and the number and nature of paramylum are different. It resembles *P. acuminatus* var *acuticauda* (Roll) Huber-Pest. (1955, figure 230) somewhat in its general shape, short nearly straight tail, two paramylum rings of unequal size and its dimensions, but differs in having a third disc-like paramylum. So, it is treated here as a new variety.

*Distribution in Indian region*: W. Bengal (!).

**9. *Phacus brachykentron* Pochmann 1942 (figures 18, 18a)**

Pochmann 1942, p. 145, figure 33; Suxena 1955, pp. 437–38, figures 6–7.

Body more or less elliptical to oval and slightly asymmetrical with a short straight or slightly bent tail; paramylum 2–3; when three in number, two central and concentric and the third excentric to the central ones; when two, one slightly lateral and the second excentric to the first; eye-spot usually small and disc-like, but sometimes horse-shoe shaped; cell  $21.5\text{--}35 \times 15\text{--}26 \mu\text{m}$ .

*Habitat*: Stray in locations 29 (November) and 154.

Pochmann gave dimensions of  $24\text{--}33 \times 15\text{--}21 \mu\text{m}$ , but typically  $30 \times 20 \mu\text{m}$ , and Suxena  $26\text{--}30 \times 20\text{--}22 \mu\text{m}$ . The present organism showed a slightly wider range.

*Distribution in Indian region*: Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1968; Kamat and Freitas 1976; Ashtekar 1982); Rajasthan (Trivedy 1982); W. Bengal and Tamilnadu (!).

**10. *Phacus inflexus* (Kisselew) Pochmann 1942 (figures 19a–b)**

Pochmann 1942, p. 133, figure 20; = *Euglena inflexa* Kisselew 1931.

Cell usually strongly twisted with inwardly curved dorsal side, looking like a sickle in side view; posterior end with a short tail lying against the dorsal side and drawn out

from a dorsal hump; pellicular striae delicate and somewhat spiral; paramylum two, one large and the other small, ovoid to discoid or elongate and rod-like; larger one usually on the dorsal side; chromatophores discoid and numerous; eye-spot small; flagellum about body length; cell  $13.5-19.4 \times 6.3-7 \mu\text{m}$ .

*Habitat:* Stray in locations 23, 30 and 33 (April).

The organism from W. Bengal is slightly smaller than Pochmann's species which measures  $24 \times 7-10 \mu\text{m}$ . Patel and Waghodekar (1981) give dimensions of  $20.4-27.2 \times 5.3-11 (-13.2) \mu\text{m}$  for their specimens from Gujarat.

*Distribution in Indian region:* Gujarat (Patel and Waghodekar 1981); W. Bengal (!).

### 11. *Phacus curvicauda* Swirenko 1915 (figures 20a-c)

Pochmann 1942, pp. 155-58, figures 49-51; Suxena 1955, p. 439, figures 10-12; Prowse 1958, p. 167, figures 3f, 3k; Hortobágyi 1969, p. 32, plate 5, figure 62.

Cell nearly round with the anterior end slightly narrow and the hind end slightly broadened and bearing at its tip a short tail which is turned slightly towards one side; apical groove of variable length ranging from about  $1/3$  to nearly the full length of the cell; pellicular striae longitudinal; chromatophores numerous and discoid; paramylum usually two discs or rings of unequal size lying laterally, very rarely only one; eye-spot discoid; cell (including tail)  $20-25-30 \times 16.7-20-27.5 \mu\text{m}$ ; tail  $2.5-5 \mu\text{m}$ .

*Habitat:* Stray in locations 28 (May), 29 (February-March), 30, 33 (May), 37a, 57 and 151 (February, October).

Pochmann gives dimensions of  $20-35 \times 18-25 \mu\text{m}$ , with  $27 \times 22-24 \mu\text{m}$  more typical, Skuja (1949)  $35 \times 28 \mu\text{m}$ , Suxena (1955)  $20-30.5 \times 22-25.5 \mu\text{m}$ , Prowse (1958)  $23-28 \times 22-25 \mu\text{m}$ , Kamat (1963, 1964)  $30-36 \times 22-32 \mu\text{m}$  and Patel and Waghodekar (1981)  $21.3-37.7 \times 16-29.3 \mu\text{m}$ . Hortobágyi (1969) gives dimensions of  $28-29.5 \times 20-23.4 \mu\text{m}$ .

*Distribution in Indian region:* Burma (Skuja 1949); Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1963, 1964, 1975, Kamat and Freitas 1976; Ashtekar 1982); Gujarat (Patel and Waghodekar 1981); Himachal Pradesh (Kamat 1968a); Uttar Pradesh (Hortobágyi 1969; Singh 1948); Karnataka (Bharati and Hosmani 1973); W. Bengal, Bihar, Orissa and Tamilnadu (!).

### 12. *Phacus textus* Pochmann 1942 (figure 21)

Pochmann 1942, p. 170, figure 67; Huber-Pestalozzi 1955, pp. 206-07, figure 263.

Cell nearly round with anterior end somewhat rounded and slightly narrower than posterior end, slightly asymmetrical; tail short, fairly stout and oblique and in continuation of one half of the cell; pellicular striae nearly vertical on one side and somewhat spiral on the other side; paramylum two, lateral, disc-like or ring-like and equal or unequal in size; eye-spot not observed; cell  $26 \times 22 \mu\text{m}$ .

*Habitat:* Stray in location 33a.

The organism was slightly smaller than the one given by Pochmann which measures  $26-30 \times 23-25.5 \mu\text{m}$ .

*Distribution in Indian region:* W. Bengal (!).

**13. *Phacus anomalus* Fritsch et Rich 1929 (figures 22a-d)**

Fritsch and Rich 1929, p. 78, figures 24 H-N; Pochmann 1942, p. 163, figures 59-60.

Cell in two unequal halves with one of the halves in the form of a wing; cell longer than broad or nearly as broad as long and winged in apical view; ends broadly rounded with the hind end somewhat broadened and with a short bent tail; pellicular striae longitudinal to slightly spiral; paramylum usually two, disc-like and unequal in size, one in each half of the cell, rarely three, two in one half of the cell and the third in the other half; one of the paramylum sometimes against the side of the cell and incised like an hour glass; cell  $23.5-28.2 \times 17.6-24.6 \mu\text{m}$ , with tail  $1.8-2.1 \mu\text{m}$ .

*Habitat:* Stray to rare in locations 2 (June), 23, 28 (April-May), 29 (January), 27a (May), 30, 40, 61 (N P 9, 10 and 16-May), 82, 89 and 91a.

Fritsch and Rich (1929) give dimensions of  $23-27$  (without tail)  $\times 26-27 \mu\text{m}$ , and thickness of  $17-22 \mu\text{m}$  while Prowse (1958) gives them as  $30-40 \times 25-30 \mu\text{m}$  and Patel and Waghodekar (1981) as  $23.6-33 \times 16.8-24.2 \mu\text{m}$ . It is possible that Prowse has mixed up *P. anomalus* and *P. inflatus* var *pterophorus* Skuja (see elsewhere in this account) since his figure 3x for *P. anomalus* looks very much like that of Skuja's variety though slightly smaller with only one paramylum.

*Distribution in Indian region:* W. Bengal (Kachroo 1960); Maharashtra (Kamat and Freitas 1976; Ashtekar 1982); Gujarat (Patel and Waghodekar 1981); Assam, W. Bengal, Madhya Pradesh and Orissa (!).

**14. *Phacus raciborskii* Drezepolski 1925 (figures 23a-e)**

Drezepolski 1925, p. 266, Tafel 3, figure 113; Pochmann 1942, pp. 174-75, figures 73-74; Bourrelly 1961, p. 305, plate 4, figure 15.

Cell made up of two thin wings, one of which stands at an angle and the other ends in a tail; dorsal side like a keel; ventral side hollowed out at an angle, the whole cell being markedly twisted; pellicular striae longitudinal and following the twist; chromatophores small, numerous and discoid; paramylum one to two ovoid to spherical discs, rarely cylindrical; cell (including tail)  $26-27.3 (-41) \times 8.8-10 \mu\text{m}$ ; tail alone  $5.3-7 \mu\text{m}$ .

*Habitat:* Stray in locations 23 and 29 (December).

Drezepolski gives the dimensions as  $35 \times 10 \mu\text{m}$ , Pochmann  $35 \times 10-12 \mu\text{m}$  and Bourrelly  $30-36 \times 10-16 \mu\text{m}$  while Prowse (1958) gives them as  $45 \times 18 \mu\text{m}$ . Patel and Waghodekar's (1981) organism measured  $23.2-31.7 \times 10.6-18.9 \mu\text{m}$ .

*Distribution in Indian region:* Maharashtra (Kamat and Freitas 1976); Gujarat (Patel and Waghodekar 1981); W. Bengal (!).

**15. *Phacus mammillatus* sp. nov. (figures 24a-c)**

Cellula torta, uno latere velut ala replicato; a superficie visa triangularis, angulis late rotundatis, unum discum paramyli perforatum satis magnum, magnitudine fere simile in omni angulo visum; cauda parva, mammiformis ad extremitatem posteriorem plicae aliformes; striae pelliculares obscurissima longitudinales ad spirales, et tortum cellulae sequenter; stigma lineiforme, ad extremitatem alae anteriorem; cellula  $35.2-37 \times 30-31.7 \mu\text{m}$ , ca.  $14 \mu\text{m}$ , crass.

*Habitatio*: Rarissima in N P 13 in Jobra, Cuttack (loc. 61) 2-8-1952 et in N P 22, Joyasagar (loc. 9) 16-3-1966.

*Iconotypus*: Figures 24a-c.

Cell twisted with one side folded back as a wing; triangular in surface view with broadly rounded angles and with one fairly large perforated paramylum disc of nearly the same size in each corner; with a small papilla-like tail at the posterior end of the wing-like fold; pellicle with very faint striae which are longitudinal to spiral and follow the twist of the cell; eye-spot streak-like and at the anterior end of the wing; cell  $35.2-37 \times 30-31.7 \mu\text{m}$  and about  $14 \mu\text{m}$  thick.

*Habitat*: Very rare in locations 9 (March) and 61 (N P 13-August).

*Type*: Figures 24a-c.

The organism comes near *P. anomalus* Fritsch *et* Rich in its being in two halves but differs in having three perforated paramylum discs of more or less equal size and the tail being very small and teat-like. So, it is treated here as a new species.

*Distribution in Indian region*: Assam and Orissa (!).

**16. *Phacus contortus* Bourrelly in Bourrelly *et* Manguin 1952 (figure 25)**

Huber-Pestalozzi 1955, pp. 204-5, figure 260A; Rino 1972, p. 152, plate V, figures 17-20.

Cell oval and in two asymmetrical twisted halves separated by two broad furrows, with one half spread out in the form of a wing which is projected backwards like a beak; with a stout oblique tail from the hind end of the other half; periplast with faint longitudinal striae following the twist; paramylum two regular or irregular discs, one in each half of the cell; cell  $35 \times 25 \mu\text{m}$ .

*Habitat*: Stray in location 76.

Bourrelly's specimens measured  $40-48 \times 28-32 \mu\text{m}$  and Rino's  $34-36 \times 24-26 \mu\text{m}$  while Bourrelly's (1961, plate V, figures 4-6) forma *minor* had dimensions of  $20-33 \times 24 \mu\text{m}$ . The author's organism is thus mid-way between the typical species and forma *minor* or nearer the latter.

*Distribution in Indian region*: Maharashtra (Kamat 1975) Orissa (!).

**17. *Phacus inflatus* Playfair 1921**

Playfair 1921, p. 124, plate V, figures 12-13; Pochmann 1942, pp. 185-86, figures 88 a-b.

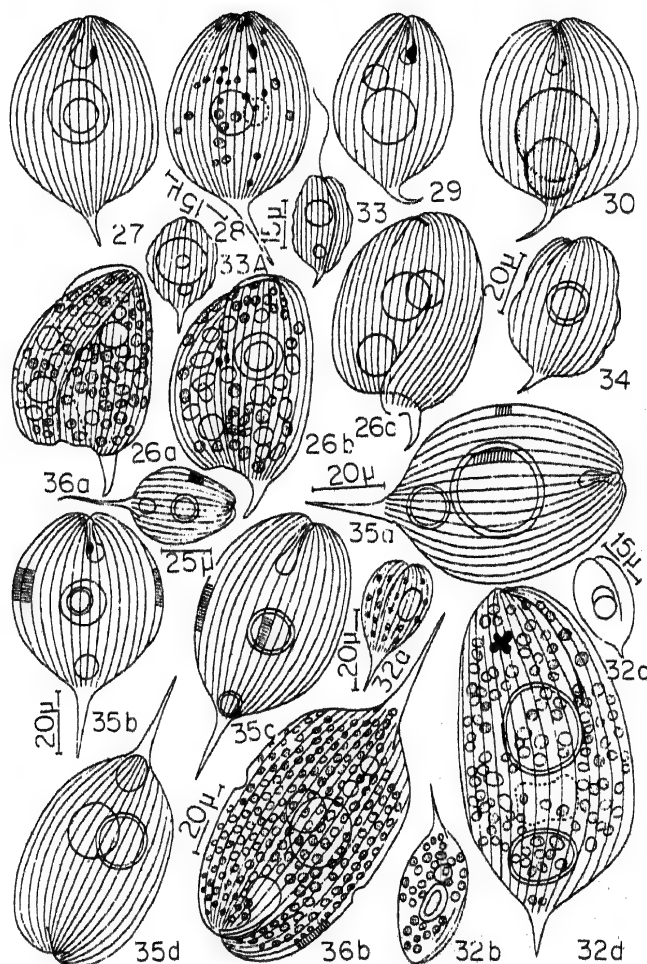


Cell in two unequal, inflated, asymmetrical lobes with one lobe longer and the other expanded more in the transverse direction; longer lobe with a short tail; paramylum a large ring in the long lobe; pellicle with longitudinal striae; eye-spot marked; flagellum long; cell  $25-32 \times 22-23 \mu\text{m}$ ; tail  $4-6 \mu\text{m}$ . The typical species is known only from Australia.

**var *pterophorus* Skuja 1949 (figures 26a-c)**

Skuja 1949, p. 164, Tafel 36, figures 29-32.

Inflation of cell less than in the typical species; cell larger with closer striae; chromatophores small, discoid and numerous; paramylum two to three discs of nearly the same size or one slightly larger; sometimes a smaller one superimposed on the larger



**Figures 26-36.** 26a-c. *P. inflatus* var *pterophorus* Skuja; 27. *P. pleuronectes* (OFM) Duj; 28. *P. platatea* Drez.; 29. *P. hamatus* Pochm.; 30. *P. orbicularis* Huebner; 32a-c. *P. caudatus* Huebner; 32d. *P. caudatus* var *major* var nov; 33. *P. ankylonoton* Pochm.; 33A. *P. formosus* Pochm.; 34. *P. undulatus* Pochm.; 35a-d. *P. meson* Pochm.; 36a. *P. ranula* Pochm.; 36b. *P. ranula* var *brevicaudatus* var nov. [Same magnification: (26a-c; 27; 32b, d); (28, 29); (30, 35b-d); (32a); (32c, 33, 33A); (34); (35a); (36a); (36b)].

one and looking ring-like; with additional paramylum bodies of smaller size; tail nearly straight or slightly curved at the tip to one side; cell  $49-54.5 \times 28-32 \mu\text{m}$  with tail alone  $7.5-9.4 \mu\text{m}$ .

*Habitat:* Rare in location 23 and stray in locations 1, 39, 61 (NP 12- May), 101a and 105.

The species agreed well with Skuja's variety measuring  $47-55 \times 30-33 \mu\text{m}$  with thickness  $20-22 \mu\text{m}$ , but the tail in the Indian material was sometimes more markedly curved towards the tip.

*Distribution in Indian region:* Burma (Skuja 1949); Assam, W. Bengal, Madhya Pradesh, Orissa and Andhra Pradesh (!).

#### 18. *Phacus pleuronectes* (OFM) Duj 1841 (figure 27)

Lemmermann 1910, p. 512, figure 4 (p. 483); Pochmann 1942, pp. 180-82, figures 82-84; Suxena 1955, p. 440, figure 22; Hortobágyi 1969, p. 32, plate V, figure 61.

Cell broadly oval and asymmetrical due to slight twisting, with one side more convex than the other; apical groove reaching up to nearly the middle of the cell; posterior end with a sharp tail bent at an angle towards one side; pellicular striae longitudinal and running to part of the tail due to torsion of the cell; paramylum two, one large and the other small, the latter superimposed on the former; body of cell  $40-45 \times 28-30 \mu\text{m}$ , with tail up to  $7 \mu\text{m}$ .

*Habitat:* One of the commonest species observed in many locations. Common in location 73, rare in locations 38 and 93a; stray in locations 2, 20, 29, 33, 36a, 57, 63 (NP 25, 29 - August, November), 70, 76, 89, 90a, 91, 93, 105, 115, 118, 124, 132, 136, 136b, 137, 145, 151 (August, March), 157 and 159.

Lemmermann (1910, 1913) gives measurements of  $45-49 \times 30-33 \mu\text{m}$ , Pochmann (1942)  $40-80 \times 30-50 \mu\text{m}$ , while Suxena (1955) gives them as  $31-37.5 \times 20-26.5 \mu\text{m}$ , Kamat (1961-62)  $37-50 \times 37-63 \mu\text{m}$  and Hortobágyi (1969)  $34-38 \times 26-29 \mu\text{m}$ . The author's specimens came between Lemmermann's and Hortobágyi's. Suxena *et al* (1973) give dimensions of  $105-110$  (including tail)  $\times 40-45 \mu\text{m}$  for their Cranganore material which is exceptional. Maximum breadth of  $63 \mu\text{m}$  given by Kamat (1961-62) is also quite high.

*Distribution in Indian region:* Kashmir (Bhatia 1930); Burma (Skvortzov 1937; Skuja 1949); Andhra Pradesh (Suxena 1955; Zafar 1959; Naidu 1962; Munawar 1972); W. Bengal (Kachroo 1960); Maharashtra (Kamat 1963, 1964, 1975; Kamat and Freitas 1976); Gujarat (Kamat 1961-62; Patel and Waghodekar 1981); Rajasthan (Trivedy 1982); Himachal Pradesh (Kamat 1968a); Uttar Pradesh (Hortobágyi 1969); Kerala (Suxena *et al* 1973); Assam, W. Bengal, Bihar, Orissa, Andhra Pradesh, Karnataka, Kerala and Tamilnadu (!).

#### 19. *Phacus platalea* Drezepolski 1925 (figure 28)

Drezepolski 1925, p. 266, Tabel 3, figure 110; Pochmann 1942, p. 179, figure 80; Huber-Pestalozzi 1955, p. 210, figure 274; Prowse 1958, p. 168, figure 3q.

Cell broadly oval and flat, slightly asymmetrical and with a sharply pointed oblique tail; paramylum a single large or medium-sized central disc; apical furrow usually reaching up to the middle only; cell (with tail)  $48-54 \times 29-32 \mu\text{m}$ ; tail alone  $10-12 \mu\text{m}$ .

*Habitat:* Stray in locations 33 (April, June), 151 (August), 154 and 156 (April).

Drezepolski (1925) gives the dimensions as  $50-56 \times 32-32.5 \mu\text{m}$ , with tail  $12-15 \mu\text{m}$ , Pochmann (1942) as  $46-52 \mu\text{m}$  in length, and Prowse (1958)  $43$  (with tail)  $\times 30 \mu\text{m}$ , tail alone  $9 \mu\text{m}$ .

*Distribution in Indian region:* Maharashtra (Kamat 1975; Kamat and Freitas 1976, Ashtekar 1982); W. Bengal and Tamilnadu (!).

## 20. *Phacus hamatus* Pochmann 1942 (figure 29)

Pochmann 1942, pp. 182-84, figure 86; Prowse 1958, p. 169, figure 3v; = *P. pleuronectes* var *citriformis* Drezepolski 1921-22; 1925, p. 266, Tafel 3, figure 117; Skvortzov 1937, p. 74, Tafel 10, figure 3.

Cell elongate-oval and somewhat asymmetrical with both ends narrowed and broadest at middle or slightly towards the base; lips at front end equal or uneven with one lip frequently larger; tail bent characteristically like a hook with its base fairly stout; paramylum usually two discs of unequal size, super-imposed and appearing as a ring or sometimes lying apart; apical furrow reaching up to the middle or slightly shorter; eyespot fairly large and nearly triangular; cell (without tail)  $35-38 \times 23-25.8 \mu\text{m}$ ; tail  $6-9 \mu\text{m}$ .

*Habitat:* Stray in locations 90 and 151 (March).

Drezepolski and Pochmann give its dimensions as  $38-45-55 \times 25-35 \mu\text{m}$  with tail  $7.5-10 \mu\text{m}$ , whereas Prowse gives them as  $37-45 \times 20-25 \mu\text{m}$  with tail  $8-12 \mu\text{m}$ .

*Distribution in Indian region:* Burma (Skvortzov 1937); Gujarat (Kamat 1961-62); Orissa and Tamilnadu (!).

## 21. *Phacus orbicularis* Huebner 1886 (figure 30)

Lemmermann 1913, p. 138, figure 256; Pochmann 1942, p. 178, figures 78-79; Suxena 1955, p. 439, figures 16-19; = *P. cingeri* Roll 1925; Skuja 1949, p. 163.

Body nearly circular; in side view dorsal side convex and ventral side nearly flat or slightly convex; in optical cross-section 3-lobed; posterior end with a short tail which is bent at an angle to the cell or sometimes more or less curved; pellicle longitudinally striated, frequently with transverse striae between the longitudinal ones; apical furrow reaching up to the middle or nearly the hind end; paramylum two, one large and central and the other small overlapping the former excentrically; cell (without tail)  $55-63 \times 40-53 \mu\text{m}$ ; tail  $15-16 \mu\text{m}$  long.

*Habitat:* Common in locations 93a and 131, stray to rare in locations 6, 18a, 25, 33 (June-July, March-April), 36a, 127, 130a and 136a.

Naidu's *P. orbicularis* (see Naidu 1966, figure 22) measuring  $60-63 \times 36-37 \mu\text{m}$

with tail  $14\text{ }\mu\text{m}$  looks more like a *P. triqueter* (Ehr) Duj (see Pochmann 1942, figure 92) since the paramylum are shown as two separate rings of more or less equal size whereas in *P. orbicularis* they are two overlapping, rarely concentric, discs of unequal size. Suxena's organism from Hyderabad measuring  $35\text{--}46.5 \times 28\text{--}31.5\text{ }\mu\text{m}$  and Suxena *et al*'s (1973) one from Kerala measuring  $44\text{--}45 \times 37\text{--}38\text{ }\mu\text{m}$  were smaller compared to the dimensions of  $50\text{--}100 \times 30\text{--}60\text{ }\mu\text{m}$  given by Pochmann. Skuja (1949) gives dimensions of  $100\text{--}102 \times 48\text{--}50\text{ }\mu\text{m}$  for his *P. cingeri* from Burma.

*Distribution in Indian region:* Maharashtra (Gonzalves and Joshi 1946, plate V, figure 13; Kamat 1964, 1968, 1975; Ashtekar 1982); Andhra Pradesh (Suxena 1955); Himachal Pradesh (Kamat 1968a); Kerala (Suxena *et al* 1973); Burma (Skuja 1949, as *P. cingeri* Roll); Assam, W. Bengal, Orissa, Karnataka and Kerala (!).

## 22. *Phacus carinatus* Pochmann 1942 (figure 31)

Pochmann 1942, pp. 187–88, figure 91; –*P. triqueter* (Ehr) Duj in Playfair 1921, p. 124, plate V, figures 8–11.

Cell resembling that of *P. pleuronectes* in shape but differing in being sharply keeled and angular with a sharply pointed oblique to curved tail which follows the contour of the cell; pellicular striae longitudinal; paramylum two discs of unequal size lying concentrically in one half of the cell or lying apart, one in each half of the cell; cell (including tail)  $34 \times 24\text{ }\mu\text{m}$ ; tail  $5\text{--}5.5\text{ }\mu\text{m}$ .

*Habitat:* Stray in location 134.

*Distribution in Indian region:* Karnataka (!).

## 23. *Phacus caudatus* Huebner 1886 (figures 32a–c)

Lemmermann 1913, p. 138, figure 237; Pochmann 1942, pp. 146–48, figures 35–36; Suxena 1955, p. 438, figure 3; Hortobágyi 1969, p. 31, plate V, figure 66; including var *ovalis* Drez 1925, p. 266, figure 111; Conrad 1938, p. 8, figures 25–26, and var *minor* Drez 1925, p. 266, figure 107.

Cell oval, slightly twisted and asymmetrical with a dorsal keel reaching up to nearly the hind end; posterior end produced into a more or less straight tail which is sometimes not clearly marked; pellicular striae longitudinal; chromatophores numerous, small and discoid; paramylum two discs or rings of unequal size usually lying along the longitudinal axis with the larger one in the middle or just above and the smaller one near the tail; frequently the larger one may be oblong to rectangular and the smaller one may be absent; cell (including tail) usually  $33\text{--}38 \times 14.3\text{--}18\text{ }\mu\text{m}$ , rarely  $25\text{--}28 \times 12.5\text{--}14.5\text{ }\mu\text{m}$ ; tail up to  $8\text{ }\mu\text{m}$ .

*Habitat:* Stray in locations 23, 28 (April), 29 (April), 63 (N P 38–August), 88, 90a and 132.

According to Pochmann (1942) there are two size groups, one with dimensions of  $34\text{--}50 \times 15\text{--}25\text{ }\mu\text{m}$  and the other (which covers var *minor* Drezepolski 1925) with dimensions of  $20\text{--}30 \times 10\text{--}15\text{ }\mu\text{m}$ . Suxena's organism ( $25\text{--}29 \times 11\text{--}25.5\text{ }\mu\text{m}$ ) comes within the latter group, his maximum breadth of  $25.5\text{ }\mu\text{m}$  being probably an error.

Kamat's (1964), Bombay material measured  $43-47 \times 20-22 \mu\text{m}$  and his Kolhapur one (Kamat 1963)  $46-50 \times 28-31 \mu\text{m}$ ; Organisms from Gujarat (Kamat 1961-62; Patel and Waghodekar 1981) measured  $40-50 \times 23-28 \mu\text{m}$  and  $21.4-42.5 \times 10.2-31.5 \mu\text{m}$  respectively. Hortobágyi's (1969) organism measured  $30-33 \times 15-17 \mu\text{m}$ . In the author's collections, the smaller form measuring  $25-28 \times 12.5-14.5 \mu\text{m}$  was noted only from one locality, viz 28, and one individual (see figure 32c) from location 29 measuring  $32 \times 17.5 \mu\text{m}$  resembled var *ovalis* in which the paramylum occur as two overlapping discs of equal size.

Naidu's (1966, figure 23) *P. trifacialis* Prowse from Andhra Pradesh measuring  $31 \times 15 \mu\text{m}$  could be a *P. caudatus* since there are two paramylum rings of unequal size in his organism whereas Prowse's (1958, p. 166) species measuring  $22-28 \times 11.3-13 \mu\text{m}$  has only a small central ring and the cell is 3-angled in optical cross-section.

*Distribution in Indian region:* Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1963, 1964, 1968, 1975); Gujarat (Kamat 1961-62; Patel and Gaghodekar 1981); Uttar Pradesh (Hortobágyi 1969); Karnataka (Bharati and Hosmani 1973); W. Bengal, Orissa and Karnataka (!).

**var major var nov. (figure 32d)**

Cellula plus minusve plana ellipsoideaque ad oblongam, extremitate posteriore paululo latiore, et in caudam brevem, rectam, crassam, cuneiformem terminante; sulcus apicalis solum usque ad circa tertiam partem longitudinis cellulae; grana paramyli ut duos anulos inaequales, maiore prae, minore post nucleum irregularem (?), omnibus tribus in linea in axe longitudinali cellulae ordinatis; stigma cruciatum, ad extremitatem anteriorem; cellula multo maior quam in specie typica,  $74$  (cum cauda)  $\times 35 \mu\text{m}$ , cauda sola  $9.2 \mu\text{m}$ .

*Habitatio:* Aberrans in cisterna stationis pro investigatione, Barrackpore (loc 29) 11-4-1950.

Cell flat and ellipsoid to oblong with the posterior end slightly broader and ending in a short, straight, wedge-shaped, stout tail; apical groove up to about a third of the length of the cell only; paramylum two unequal rings with the larger one in front and the smaller one behind an irregular nucleus (?) the latter one being near the tail; eye-spot cruciate and at the anterior end; cell much larger than in the typical species measuring  $74$  (including tail)  $\times 35 \mu\text{m}$ ; tail alone  $9.2 \mu\text{m}$ .

*Habitat:* Stray in location 29 (April).

In general organisation, the present organism agreed well with *P. caudatus* Huebner, but was much larger. It is, therefore, treated here as a new variety of *P. caudatus*.

It resembled the figure for *P. caudatus* given by Pochmann (1942, figure 36) after Krischenbauer in its shape and the cruciate eye-spot, but in Krischenbauer's organism the arrangement of the paramylum was different, the tail was slightly curved and the size of the cell was also smaller (about  $32 \times 16.5 \mu\text{m}$ , from the scale given).

*Distribution in Indian region:* W. Bengal (!).

**24. *Phacus ankylonoton* Pochmann 1942 (figure 33)**

Pochmann 1942, pp. 148–49, figure 37.

Cell elongate-oval with a dorsal thickening; more or less three-edged in optical cross-section; flanks of cell entire or irregularly crenate; paramylum two, along the longitudinal axis, with the anterior one larger; tail straight or slightly curved; pellicular striae longitudinal; cell  $37 \times 18 \mu\text{m}$ .

*Habitat*: Stray in location 28 (April).

*Distribution in Indian region*: Gujarat (Patel and Waghodekar 1981, p. 31); W. Bengal (!).

**24A. *Phacus formosus* Pochmann 1942 (figures 33A, 33A<sub>1</sub>)**

Pochmann 1942, p. 149, figure 38.

Cell elongate-oval with the lips at the anterior end somewhat curved and a tail which is usually straight: flanks of cell entire or slightly and irregularly crenate; in optical cross-section three-edged; with a dorsal thickening from the anterior to the very posterior end; paramylum two, the anterior one being disc-like or ring-like and exceptionally large nearly filling the cell; the posterior one small, slightly elongate and disc-like, and lying very near the larger one or partly overlapped by it; eye-spot not observed; cell  $38-41 \times 22.5 \mu\text{m}$ ; tail alone  $6.5 \mu\text{m}$ .

*Habitat*: Stray in locations 18a and 73.

The organism agreed well with Pochmann's species except that it was slightly broader, the breadth given by Pochmann being about  $20 \mu\text{m}$ . The large eye-spot also could not be observed in the preserved material.

*Distribution in Indian region*: Assam and Orissa (!).

**24B. *Phacus obolus* Pochmann 1942 (figure 33B)**

Pochmann 1942, p. 153, figure 43; = *P. caudatus* var *lata* Allorge et Lefèvre 1930.

Cell more or less rectangular and about twice as long as broad with the sides nearly parallel; tail straight; pellicle striated longitudinally; paramylum a large central disc; 1–3 additional small paramylum frequently present; cell (including tail)  $30-32 \times 17.5-18.7 \mu\text{m}$ ; tail alone  $4.8 \mu\text{m}$ .

*Habitat*: Stray in locations 28 (May) and 29 (April).

Pochmann gives its dimensions as  $28-33 \times 13-20 \mu\text{m}$ . Additional paramylum were not observed in the author's material.

*Distribution in Indian region*: W. Bengal (!).

**25. *Phacus undulatus* (Skv) Pochmann 1942 (figure 34)**

Pochmann 1942, p. 191, figures 95–96; = *P. orbicularis* var *undulata* Skvortzov 1917; = *P. anacoelus* var *undulata* Skvortzov 1928; Skuja 1949, p. 163.



Cell oval and asymmetrical with the anterior half narrower; tail small and oblique; lateral margins of cell irregularly crenate; pellicular striae longitudinal; paramylum one large central ring or two unequal discs arranged concentrically or sometimes overlapping; cell  $55 \times 30-35 \mu\text{m}$ .

*Habitat:* Stray in locations 28 (May), 73 and 104a.

Pochmann (1942) gives dimensions of  $50-80 \times 30-48 \mu\text{m}$ .

*Distribution in Indian region:* Maharashtra (Kamat and Freitas 1976); W. Bengal, Orissa and Andhra Pradesh (!); Burma (Skuja 1949).

## 25A. *Phacus onyx* Pochmann 1942 (figure 34A)

Pochmann 1942, pp. 192-93, figures 98 a-d, Suxena 1955, p. 440, figures 51-52, 56; Prowse 1958, p. 171, figures 3 m-n, x.

Cell slightly asymmetrical and more or less trapezoidal with the posterior end abrupt and with a sharply curved tail; anterior end narrower; one or both margins of cell with a notch; pellicle with longitudinal striae; paramylum a single large disc (or ring) or rarely two smaller ones; cell (including tail)  $40-47 \times 28-32.5 \mu\text{m}$ ; tail alone up to  $10 \mu\text{m}$ .

*Habitat:* Stray in locations 28 (April), 63 (N P 31-March) and 73 (February).

Pochmann gives its dimensions as  $30-42 \times 22-35 \mu\text{m}$ , Suxena as  $32-36 \times 23-26.5 \mu\text{m}$  and Prowse as  $50-55 \times 35-37 \mu\text{m}$  with tail  $14-17 \mu\text{m}$ . In Suxena's material there were two notches on one margin and none on the other.

The organism differs from *P. undulatus* in that the lateral margins are not crenate, the tail is more sharply curved and in its usually smaller size. The paramylum is also more commonly a single central disc.

*Distribution in Indian region:* Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1963; Kamat and Freitas 1976; Ashtekar 1982); W. Bengal and Orissa (!).

## 26. *Phacus meson* Pochmann 1942 (figures 35a-d)

Pochmann 1942, pp. 195-96, figure 103; Suxena 1955, pp. 440-42, figure 50; = *P. longicauda* var *brevicaudata* Skvortzov 1922; = *P. longicauda* var *indica* Skvortzov 1937, p. 73, Tafel 9, figure 15 and Table 10, figure 1.

Cell elongate-ellipsoid to oval with the anterior end rounded; posterior end continued as a medium-sized tail; pellicle with longitudinal striae and frequently with close transverse striae between them; chromatophores small, numerous and discoid; paramylum two equal or unequal rings or discs, one at the centre and the other at the posterior end near the tail, rarely three, two at the centre (concentric or slightly overlapping) and the third at the hind end; lateral margins of cell entire; cell (including tail)  $86-105 \times 47.5-51 \mu\text{m}$ ; tail alone  $23-30 \mu\text{m}$ .

*Habitat:* Rather common to common in locations 6, 33 (April) and 40; stray to rare in locations 13, 17, 20, 43a, 46, 55a, 57, 60, 61 (N P 3 & 5-May), 63 (N P 27-July), 70, 73,

76, 77a, 83, 84, 86, 88, 89, 93, 103a, 104, 115, 133a, 136a and 152a (February).

The species agreed well with Skvortzov's (1937) organism from Rangoon but differed in the presence of transverse striae between the longitudinal ones in the majority of specimens and the lateral margins of cells in all the specimens observed being entire, none with lateral notches being seen. Apart from the cells being slightly larger than Skvortzov's ( $89-93 \times 25-40 \mu\text{m}$ ), occasionally three paramylum were also observed. Suxena's (1955) organism from Hyderabad ( $100-102 \times 49-50 \mu\text{m}$ ) with transverse striae agreed with the author's but he, like Prowse (1962, plate 1, figure n) in the Malaysian specimens ( $75-80 \times 50 \mu\text{m}$ ; tail alone  $30 \mu\text{m}$ ) observed only two paramylum. No transverse striae were observed by Prowse. Kamat (1968) gives the breadth of his Alibag specimens as up to  $55 \mu\text{m}$ .

Naidu (1966, p. 28, figure 24) gives dimensions of his *P. meson* from Vijayawada as  $200-220 \times 85-90 \mu\text{m}$ . He does not give further details except mentioning that it is larger than the typical *P. meson*. His figure showing two paramylum rings resembles that of *P. meson*. If its dimensions are correct, it will have to be treated as a new taxon, viz *P. meson* var *major* (Naidu) var *nov.* since it is much larger than the typical species.

Kamat's (1964, figure 1) *P. maharastrensis* from Bombay with cylindric-ellipsoid cell having dimensions of  $110-130 \times 45-52 \mu\text{m}$ , with tail  $40-45 \mu\text{m}$ , appears to be a slightly larger *P. meson*. In fact it resembles Skvortzov's (1937) Burmese organism measuring  $93 \times 25 \mu\text{m}$  in all respects (see Pochmann 1942, figure 103c and Huber-Pestalozzi 1955, figure 294c), except size, the fewer striae (eight compared to ten shown in Skvortzov's figure) and the slightly larger paramylum. The striae are also not shown correctly in Kamat's figure.

**Distribution in Indian region:** Burma (Skvortzov 1937), Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1968); Assam, W. Bengal, Madhya Pradesh, Orissa, Andhra Pradesh, Karnataka, Kerala and Tamilnadu (!).

## 27. *Phacus ranula* Pochmann 1942 (figures 36a, g, h)

Pochmann 1942, p. 212, figure 126; Huber-Pestalozzi 1955, p. 227, figures 313 a-d only; Prowse 1958, p. 172, figures 4 g, h.

Cell more or less elliptic to oval and flat or slightly twisted; anterior end broadly rounded, posterior end slightly broader and with a distinctly kinked (twisted backwards) tail which starts slightly at an angle to the posterior end and not continuous with it; cell margins entire; pellicle with longitudinal striae with transverse striae in between them; chromatophores small, numerous and discoid; paramylum three or more discs (concentric or otherwise) of variable size and lying mostly in the posterior half; cell (excluding tail)  $57.5-65 \times 37.5-45 \mu\text{m}$ ; tail  $37.5-46 \mu\text{m}$ .

**Habitat:** Stray in locations 4a, 5, 63 (N P 29-November), 83 and 115; rather common in location 104a.

Pochmann gives dimensions of  $80$  (without tail)  $\times 55 \mu\text{m}$ , with tail about  $50 \mu\text{m}$  and Prowse  $90$  (including tail)  $\times 37 \mu\text{m}$  with tail  $37 \mu\text{m}$ . The Assam material (locations 4a and 5) was nearer the Malaysian one.

**Distribution in Indian region:** Assam, Orissa and Andhra Pradesh (!).

**var brevicaudatus var nov. (figures 36b–d)**

Including *P. ranula* Pochmann p.p. in Huber-Pestalozzi 1955, p. 227, figure 313e only.

Varietas a varietate typica differens ut cauda brevior et fere recta aut cacumen versus paulum flexa, non, autem torta, cellula necnon crassior quam varietas typica; margines laterales cellulae aut integri aut interdum incisi; striae transversae inter striae longitudinales praesentes absentesve; grana paramyli quattuor ad numerosa, discoidea, annularia aut ambo, magnitudine variantia; stigma distinctum; flagellul non observatum; cellula (cauda exclusa)  $74-83 \times 38.5-47.5 \mu\text{m}$ , cauda  $24.5-33 \mu\text{m}$ .

*Habitatio*: Rara in palude, Kausalyagang, Puri (loc. 92) 10-4-1951 et aberrans in loco Thandankulam, Azhicode, Trichur dicto (loc. 136a) 26-2-1949.

Differs from the typical species in the tail being shorter and nearly straight or only very slightly bent towards the tip, but not twisted, also stouter than in the type; lateral margins of cell either entire or sometimes with a notch; transverse striae present or absent; paramylum four to numerous, ring-like, disc-like or both and of variable size; eye-spot distinct; flagellum not observed; cell (excluding tail)  $74-83 \times 38.5-47.5 \mu\text{m}$ ; tail  $24.5-33 \mu\text{m}$ .

*Habitat*: Rare in location 92 and stray in location 136a.

Huber-Pestalozzi (1955) states that though the tail of *P. ranula* is usually twisted irregularly it is occasionally straight. His figure 313e also shows that the tail is shorter than in the typical species. There are also numerous paramylum bodies. Some of the author's specimens with numerous paramylum were exactly like Huber-Pestalozzi's specimens. Since the material from both the locations mentioned above had consistently short nearly straight tails, it appears to the author that it could be treated as a new variety, viz var *brevicaudatus*. Though the organism looks very much like *P. meson* it can be distinguished from it by the origin of the tail at an angle to the posterior end of the cell and the larger number of paramylum.

*Distribution in Indian region*: Orissa and Kerala (!).

**var africana Bourrelly 1961 (figures 36e–f)**

Bourrelly 1961, p. 305, figures 7–8.

Differs from the typical species in its regularly elliptical cell, its smaller size and in the presence of two large central paramylum which appear as a biconvex lens; additional smaller paramylum discs present around the central ones; tail somewhat recurved; periplast with longitudinal striae; cell (excluding tail)  $40.5-48 \times 27.3-31.5 \mu\text{m}$ ; tail alone  $31-33.5 \mu\text{m}$ .

*Habitat*: Stray in locations 20 and 23.

The Indian organism agreed fairly well with Bourrelly's variety ( $47-50 \times 33-34 \mu\text{m}$  with tail  $33-35 \mu\text{m}$ ). However, the minute perforations in some of the smaller paramylum discs reported by him could not be observed. The range of dimensions was also larger.

*Distribution in Indian region*: Assam and W. Bengal (!).

## 28. *Phacus longicauda* (Ehr) Duj 1841 (figures 37a–b)

Lemmermann 1910, p. 511, figure 24 (p. 483); Huber-Pestalozzi 1955, p. 220, figure 299; = *Euglena longicauda* Ehr 1838; = *Phacus longicauda* subsp. *cordata* Pochmann 1942, pp. 199–200, figures 109–10.

Cell usually obovate or cordate, sometimes otherwise, asymmetrical, markedly flattened and broadest in the front one-third or half; anterior end broadly rounded and with uneven lips; tapering towards the posterior end evenly and more or less quickly to end in a long straight or distinctly curved tail; pellicle with longitudinal striae which converge towards the ends; lateral margins of cell usually entire, rarely with a notch; paramylum one to two (concentric or lying apart) discs; cell (including tail)  $108\text{--}141 \times 45\text{--}47.5\text{ }\mu\text{m}$ ; tail  $59\text{--}64\text{ }\mu\text{m}$ .

*Habitat*: Stray to very rare in locations 4, 17, 23, 33 (October), 38, 76, 78, 92, 103a, 124, 127 and 151; rather common in location 93a.

Measurements given by Pochmann (1942) are  $85\text{--}190$  (including tail)  $\times 40\text{--}75\text{ }\mu\text{m}$  and by Skuja (1949)  $80\text{--}130 \times 31\text{--}57\text{ }\mu\text{m}$ . According to Huber-Pestalozzi (1955) Pochmann's *P. longicauda* subsp. *cordata* has to remain as the typical species since the original species described by Ehrenberg was cordate, and Pochmann has not given any typical species. In *P. longicauda* the eye-spot is described as large, but in the author's material it was small though distinct. Though the paramylum in the author's material was usually in the form of a ring, occasionally there were 2–3 separate discs instead of a ring.

Kamat (1961–62, 1963, 1964) gives dimensions of  $80\text{--}110 \times 40\text{--}70\text{ }\mu\text{m}$  for his specimens from Gujarat and Maharashtra while Suxena *et al* (1973) give them as  $104\text{--}114 \times 85\text{--}86\text{ }\mu\text{m}$  with tail  $95\text{--}96\text{ }\mu\text{m}$  for their Kerala material.

*Distribution in Indian region*: Kashmir (Bhatia 1930); Gujarat (Kamat 1961–62); Maharashtra (Kamat 1964, 1968, 1973, 1974; Kamat and Freitas 1976); Kerala (Suxena *et al* 1973); Burma (Skuja 1949); Assam, W. Bengal, Bihar, Orissa, Andhra Pradesh, Karnataka and Tamilnadu (!).

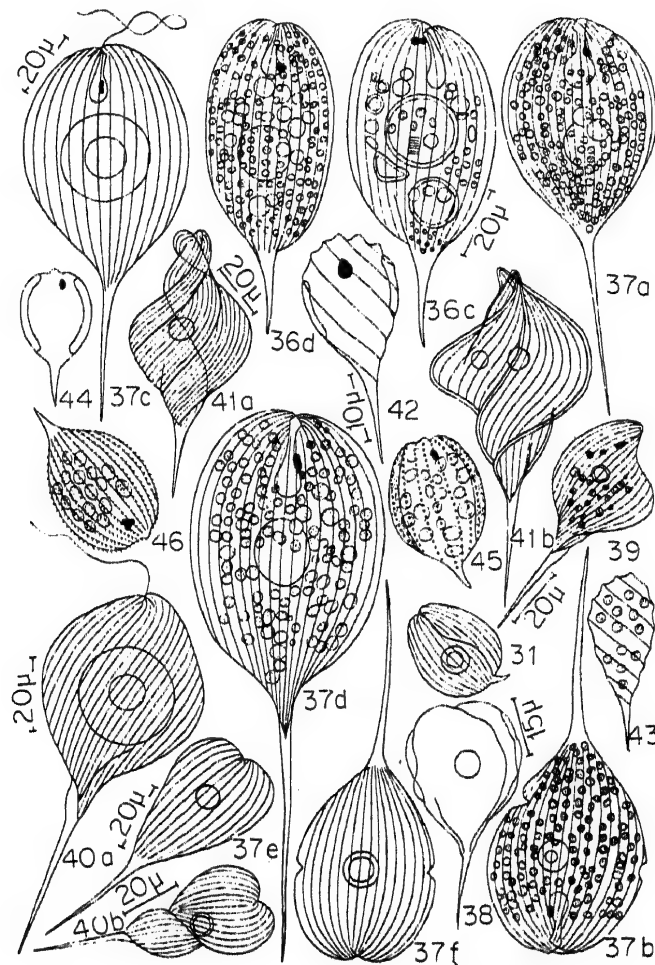
## var *rotunda* (Pochmann) Huber-Pest. 1955 (figures 37c, g, h)

Huber-Pestalozzi 1955, p. 222, figure 300; = *P. longicauda* subsp. *rotunda* Pochmann 1942, pp. 201–2, figure 111.

Cell oval and slightly asymmetrical with both ends more or less rounded; tail long and slightly oblique or bent; pellicular striae longitudinal and converging towards both ends; paramylum a single central small or large disc or ring (or concentric discs of unequal size) or two overlapping discs; cell (including tail)  $114\text{--}125 \times 48\text{--}55\text{ }\mu\text{m}$ ; tail alone  $43\text{--}50\text{ }\mu\text{m}$ .

*Habitat*: Stray to rare in locations 4, 6, 17, 28 (April), 29 (June), 33 (April), 50, 76, 85, 88, 93a, 111 and 151.

Pochmann gives dimensions of  $100\text{--}170\text{ }\mu\text{m}$ , usually  $160\text{ }\mu\text{m}$ , and states that they are variable. He also states that there are fine transverse striae between the longitudinal ones. In the present study these were not observed. Prowse (1958) gives dimensions of



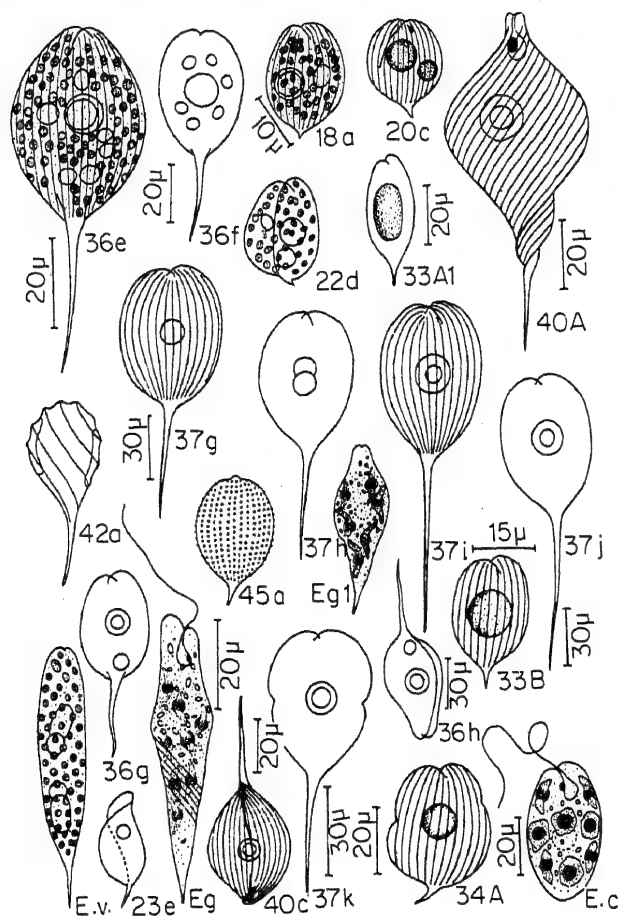
Figures 31, 36-46. 31. *P. carinatus* Pochm., 36c-d. *P. ranula* var *brevicaudatus*. var nov. 37a-b. *P. longicauda* (Ehr) Duj; 37c. *P. longicauda* var *rotunda* (Pochm.) Huber-Pest.; 37d. *P. longicauda* var *maior* Swir.; 37e. *P. longicauda* var *attenuata* (Pochm.) Huber-Pest.; 37f. *P. longicauda* var *insecta* Kocz.; 38. *P. ephippion* Pochm.; 39. *P. circumflexus* Pochm.; 40a-b. *P. tortus* (Lemm.) Skvortz.; 41a-b. *P. helikoides* Pochm.; 42. *P. pyrum* (Ehr) Stein; 43. *P. atrakoides* Pochm.; 44. *P. glaber* (Defl) Pochm.; 45. *P. suecicus* Lemm.; 46. *P. hispidula* (Eichw.) Lemm. [Same magnification: (31, 37e); (36c-d; 37a-b, d; 41a); (37c; 39); (38); (40a, 41b, 43, 44, 45, 46); (42)].

35-140 (including tail)  $\times$  35-50  $\mu$ m, with tail alone 40-60  $\mu$ m. Obviously, the minimum length of 35  $\mu$ m with tail is a printing error. Though Pochmann and Huber-Pestalozzi refer to the paramylum as a disc, Pochmann's figure 111c (after Lefèvre 1931) and 111e and Huber-Pestalozzi's figure 300c (both after Ehrenberg) show a large ring-like one.

**Distribution in Indian region:** Maharashtra (Kamat 1975); Assam, W. Bengal, Orissa, Andhra Pradesh and Tamilnadu (!).

**var *maior* Swirenko 1915 (figures 37d, i, j)**

Huber-Pestalozzi 1955, p. 223, figure 302; = *P. longicauda* subsp. *maior* Pochmann 1942, p. 203, figure 113; = *P. longicauda* (Ehr) Duj in Playfair 1921, p. 124, plate figure 6.



**Figure 18a.** *P. brachykentron* Pochm.; **20c.** *P. curvicauda* Swir.; **22d.** *P. anomalus* Fritsch *et Rich*; **23e.** *P. raciborskii* Drez.; **33A1.** *P. formosus* Pochm., side view; **33B.** *P. obolus* Pochm.; **34A.** *P. onyx* Pochm.; **36e–f.** *P. ranula* var *africana* Bourr.; **36g–h.** *P. ranula* Pochm.; **37g–h.** *P. longicauda* var *rotunda* (Pochm.) Huber-Pest.; **37i–j.** *P. longicauda* var *maior* Swir.; **37k.** *P. longicauda* var *insecta* Kocz.; **40A.** *P. sesquitortus* Pochm.; **40c.** *P. tortus* (Lemm) Skv.; **42a.** *P. pyrum* (Ehr) Stein; **45a.** *P. suecicus* (Lemm) Lemm.; **Ec.** *Euglena clara* Skuja; **Eg1–E.** *E. granulata* (Klebs) Schmitz; **Ev.?** Free living cell of *E. vaginicola* Philipose. [Same magnification: (18a); (20c, 22d, 23e, 36e, 42a, Ev); (33A1, 33B); (36g–h); (36f); (34A, 45a, Eg1); (37g–h); (37i–j); (37k); (40A); (40c)].

Cell more or less symmetrical and oval; tail usually very straight, rarely bent, and characteristically long; paramylum usually a single central ring or two discs of unequal size lying concentrically, rarely a large single (?) disc; eye-spot distinct; cell (including tail)  $145\text{--}156\text{--}172 \times 49\text{--}54 \mu\text{m}$ ; without tail  $49\text{--}84 \mu\text{m}$  long; tail alone  $68\text{--}75\text{--}92 \mu\text{m}$ .

**Habitat:** Rather common in location 151 (February); stray in locations 33 (April), 57, 73, 85, 100a, 111 and 151 (March).

Pochmann gives dimensions of  $53\text{--}90 \mu\text{m}$  (excluding tail) and  $170\text{--}188$  (including tail)  $\times 40\text{--}65 \mu\text{m}$ , with tail alone up to  $100 \mu\text{m}$ . In the author's material most specimens showed a tail which was as long as the body, but specimens from locations 57 and 73 (figures 37i and 37j respectively) were more typical with longer tail.

**Distribution in Indian region:** Maharashtra (Kamat 1975); W. Bengal, Orissa, Andhra Pradesh and Tamilnadu (!).



**var attenuata (Pochm) Huber-Pest. 1955 (figure 37e)**

Huber-Pestalozzi 1955, p. 222, figure 301; = *P. longicauda* subsp. *attenuata* Pochmann 1942, p. 202, figures 112 a-c; = *P. longicauda* (Ehr) Duj in Skvortzov 1937, p. 73, Tafel 10, figure 2.

Cell flat and elongate-oval to club-shaped with the anterior end broader; posterior end narrow and asymmetrical; tail about body length; with a central disc-like paramylum; cell  $83 \times 30 \mu\text{m}$ ; tail alone  $35 \mu\text{m}$ .

*Habitat*: Stray in locations 40, 76 and 98a.

*Distribution in Indian region*: Burma (Skvortzov 1937); Madhya Pradesh and Orissa (!).

**var insecta Koczwara 1915 (figures 37f, k)**

Huber-Pestalozzi 1955, p. 223, figure 303; Skvortzov 1937, p. 73, Tafel 9, figure 6; = *P. longicauda* subsp. *insecta* (Koczwara) Pochmann 1942, p. 204, figure 115.

Cell pear-shaped with the tail more or less bent, and with a notch on each lateral margin of the cell; paramylum single, central and ring-like; cell (including tail)  $90-120 \times 42-45 \mu\text{m}$ ; tail alone up to  $60 \mu\text{m}$ .

*Habitat*: Stray in locations 5, 17, 45, 61 (NP 11-May), 63 (NP 38-September), 73, 83, 84, 88 and 127.

Pochmann and Huber-Pestalozzi give dimensions of  $80-130 \times 35-44 \mu\text{m}$  and Skvortzov  $136 \times 47 \mu\text{m}$ .

*Distribution in Indian region*: Burma (Skvortzov 1937); Assam, Orissa and Karnataka (!).

**29. *Phacus ehippion* Pochmann 1942 (figure 38)**

Pochmann 1942, p. 208, figure 120; Suxena 1955, p. 442, figures 32 a-b; = *P. longicauda* var *torta* Lemm. in Fritsch and Rich 1929, p. 76, figures B-F.

Cell pear-shaped and curved like a saddle with folds along the margins; anterior end broadly rounded; posterior end produced into a short tail about half the length of the body; paramylum a large central disc; cell (including tail)  $60 \times 35 \mu\text{m}$ .

*Habitat*: Stray in location 76.

Fritsch and Rich give dimensions of  $60-75 \times 31-41 \mu\text{m}$ , Suxena  $61-63.5 \times 30-32 \mu\text{m}$  and Suxena *et al* (1973)  $66-68 \times 32-34 \mu\text{m}$ .

*Distribution in Indian region*: Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1975); Kerala (Suxena *et al* 1973); Orissa (!).

**30. *Phacus circumflexus* Pochmann 1942 (figure 39)**

Pochmann 1942, pp. 206-8, figure 119; Suxena 1955, p. 442, figure 39; = *P. torta* (Lemm) Skvortzov 1937, p. 72, Tafel 9, figure 3.

Cell more or less asymmetrical and more unequally bent than twisted; anterior end somewhat pointed with the lips close together; posterior end with a straight, bent or slightly twisted tail; pellicular striae prominent and spiral; apical furrow reaching up to the middle; paramylum central and ring- or spool-shaped or oval, sometimes with an additional basal grain; cell  $73-90 \times 34-45 \mu\text{m}$ .

*Habitat:* Stray in locations 33 (April, May, November), 63 (N P 24–August), 104; rare in location 151 (January).

Pochmann gives dimensions of  $79-90 \times 34-45 \mu\text{m}$  for this species.

*Distribution in Indian region:* Burma (Skvortzov 1937); Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1975); W. Bengal, Orissa, Andhra Pradesh and Tamilnadu (!).

### 31. *Phacus tortus* (Lemm) Skvortzov 1928 (figures 40a–c)

Pochmann 1942, p. 209, figures 121 a–d; Suxena 1955, p. 443, figure 37; Hortobágyi 1969, p. 32, plate 5, figure 60; = *P. longicauda* var *torta* Lemm. 1910, p. 511; Skuja 1949, p. 164.

Cell slightly twisted, the number of twists being usually one, and usually symmetrical in relation to the middle line; anterior and posterior ends narrowed, broadest at middle; posterior end produced into a long, straight or slightly bent tail; pellicle with longitudinal striae which follow the twist; with one large or medium-sized, central, ring-like (or two super-imposed disc-like) paramylum; flagellum about body length; cell (including tail)  $79-82.5 \times 31.5-34 \mu\text{m}$ ; tail alone  $30.5-33 \mu\text{m}$ .

*Habitat:* Widely distributed. Stray in locations 4, 20, 28 (May), 29 (June, December), 33 (April), 40a, 57, 61 (N P 16–May), 76, 83, 88, 89, 90, 90a, 93, 101, 104 and 154.

Pochmann (1955) gives measurements of  $80-112$  (including tail), more commonly  $80-90 \times 38-52 \mu\text{m}$ ,  $40-45 \mu\text{m}$  being the more common breadth. Suxena gives the dimensions as  $73-79 \times 34-38 \mu\text{m}$  and Prowse (1958)  $80-85$  (including tail)  $\times 27-36 \mu\text{m}$ , with tail alone  $30-33 \mu\text{m}$ , while Kamat (1963, 1964) gives  $70-90 \times 25-35-40 \mu\text{m}$  for his Maharashtra material. Hortobágyi's (1969) organism measured  $64-70.2 \times 24.7-30.5 \mu\text{m}$ , with tail  $18-23 \mu\text{m}$ . Naidu's (1966, figure 25) *P. tortus* with two lateral folds towards the anterior end and measuring  $77-100 \times 40-? 40 \mu\text{m}$ , with tail  $28-32 \mu\text{m}$ , is not typical.

*Distribution in Indian region:* Andhra Pradesh (Suxena 1955; ? Naidu 1966); Maharashtra (Kamat 1963, 1964, 1975); Uttar Pradesh (Hortobágyi 1969); Burma (Skuja 1949); Assam, W. Bengal, Madhya Pradesh, Orissa, Andhra Pradesh and Tamilnadu (!).

#### 31A. *Phacus sesquitortus* Pochmann 1942 (figure 40A)

Pochmann 1942, pp. 209, 212, figure 123; = *P. longicauda* (Ehr) Duj var in Playfair 1921, p. 124, plate 5, figure 7.

Cell with only about  $1\frac{1}{2}$  twists and a ridge only on one side; striae spiral and following

the twists; with a moderately long tail; paramylum usually a central ring; with a large disc-like eye-spot at the anterior end; cell (including tail)  $90.6 \times 42.2 \mu\text{m}$ ; tail alone  $30.8 \mu\text{m}$ .

*Habitat*: Stray in location 33 (April).

Pochmann gives its dimensions as  $62-90 \times 40-54 \mu\text{m}$  and states that morphologically the organism comes between *P. tortus* and *P. helikoides*.

*Distribution in Indian region*: W. Bengal (!).

### 32. *Phacus helikoides* Pochmann 1942 (figures 41a-b)

Pochmann 1942, p. 212, figure 125; Prowse 1958, p. 172, figure 4f; = *P. torta* (Lemm) var *tortuosa* Skvortzov 1928; 1937, p. 72, Tafel 9, figure 14.

Cell spirally twisted (usually 3 twists) with the anterior end slightly narrowed and ending in a forked cleft; cell markedly broad in the anterior third, and with a straight hyaline tapering tail at the posterior end; outline of cell like a delta; dorsal and ventral sides forming a spiral keel from the middle of the cell and appearing more pronounced towards the posterior end which appears four-sided in optical cross-section; pellicular striae spiral and following the twists; paramylum a central ring or disc, rarely two; cell (including tail)  $91-111 \times 42-49 \mu\text{m}$ , with tail alone  $31-38 \mu\text{m}$ .

*Habitat*: Common in locations 33 (April) and 61 (N P 15-May); stray in locations 56, 76, 90, 91, 126, 133a and 136a.

Pochmann (1942) gives its measurements as  $70-120 \times 30-54 \mu\text{m}$  while Kamat (1964) gives them as (67-)  $80-110 \times 32-40 \mu\text{m}$ . Malaysian specimens (see Prowse 1958) measured  $95-100 \mu\text{m}$  (including tail)  $\times 42 \mu\text{m}$ , tail  $25 \mu\text{m}$ .

*Distribution in Indian region*: Burma (Skvortzov 1937); Maharashtra (Kamat 1964); W. Bengal, Orissa, Karnataka and Kerala (!).

## Section II. *Pleurapsis* Pochmann 1942

### 33. *Phacus pyrum* (Ehr) Stein 1878 (figure 42, 42a)

Lemmermann 1910, p. 515, figure 8 (p. 483); Pochmann 1942, pp. 216-19, figures 131-32.

Cell elongate pear-shaped and in optical cross-section nearly rounded; usually asymmetrical with a straight or slightly oblique tail; anterior end slightly narrowed with the periplast knotted or with an apical notch; pellicle with ribs running to the left; paramylum two and in the form of two lateral pads; chromatophores small, numerous and discoid; eye-spot prominent; cell (including tail)  $36-39 \times 15.5-16.7 \mu\text{m}$ ; tail alone  $13.8-15.8 \mu\text{m}$ .

*Habitat*: Stray in locations 18, 28 (April, November), 29 (April), 32 (November), 33 (September), 73, 76, 78, 83a, 93, 112a, 136a and 151.

Pochmann (1942) gives its measurements as  $30-55 \times 7(?) - 21 \mu\text{m}$  while Lemmermann (1910) gives them as  $30-55 \times 13-15 \mu\text{m}$ .

*Distribution in Indian region:* Burma (Skuja 1949); Assam, W. Bengal, Orissa, Andhra Pradesh, Kerala and Tamilnadu (!).

**34. *Phacus atrakoides* Pochmann 1942 (figure 43)**

Pochmann 1942, p. 219, figure 133; = *P. pyrum* (Ehr) Stein in Skvortzov 1937, p. 75, Tafel 9, figure 22.

Cell spindle-shaped and in optical cross-section three-angled; anterior end rounded; posterior end gradually drawn out into a pointed tail; pellicle with spiral ribs running to the left; chromatophores numerous and discoid; cell  $28-30 \times 9-10 \mu\text{m}$ .

*Habitat:* Stray in location 112a.

Pochmann (1942) gives its dimensions as  $30 \times 10 \mu\text{m}$ .

*Distribution in Indian region:* Burma (Skvortzov 1937); Andhra Pradesh (!).

**Section III. *Acanthopeltis* Pochmann 1942**

**35. *Phacus glaber* (Defl) Pochmann 1942 (figure 44)**

Pochmann 1942, p. 236, figures 160 a-d; Prowse 1958, p. 173, figure 4d; = *P. hispidula* (Eichw) Lemm. fa *glabra* Deflandre 1930.

Cell broadly oval, elliptic in side view and with an acicular or awl-shaped tail at the posterior end; anterior end with a short papilla; cell wall smooth; paramylum two lateral pads; eye-spot prominent; chromatophores small, numerous and discoid; cell (including tail)  $26.5 \times 14.5 \mu\text{m}$ ; tail alone  $7 \mu\text{m}$ .

*Habitat:* Stray in location 67.

Pochmann does not give its dimensions but states that the species is essentially like *P. suecicus* without wart-like excrescences. Prowse gives its dimensions as  $26 \times 19 \mu\text{m}$ .

*Distribution in Indian region:* Orissa (!).

**36. *Phacus suecicus* (Lemm) Lemm 1913 (figures 45, 45a)**

Lemmermann 1913, p. 139; figure 241; Pochmann 1942, pp. 233-35, figures 155 and 156 a-i; = *P. moniliata* var *suecica* Lemm 1904, p. 125, Tafel 1, figure 15; = *P. hispidula* (Eichw) Lemm var *suecica* Lemm 1910, p. 516; Skuja 1949, p. 164.

Cell broadly ovoid to ellipsoid and slightly asymmetrical; elliptical in side view; anterior end somewhat truncate slopingly or retuse with a central papilla; posterior end with a short stout slightly oblique or curved tail; pellicle with variable number (usually up to about 14) of longitudinal rows of wart-like excrescences or tubercles; chromatophores small, numerous and discoid; paramylum two lateral pads; eye-spot prominent; cell (including tail)  $33.5 \times 18.5 \mu\text{m}$ ; tail  $6.2 \mu\text{m}$ .

*Habitat:* Stray in locations 34, 61 (N P 15-November; N P 17-May), 70, 73, 89 and 93.

Lemmermann (1913) gives its measurements as  $34 \times 20-21 \mu\text{m}$  while Pochmann (1942) gives them as  $19-22$  (mostly  $20$ )  $\mu\text{m}$ , with thickness  $6-11 \mu\text{m}$ . Playfair (1921) gives them as  $30-34 \times 23-24 \mu\text{m}$  with thickness  $6 \mu\text{m}$  and tail  $7-8 \mu\text{m}$  in his *P. moniliata* var *suecica* Lemm.

*Distribution in Indian region:* Burma (Skuja 1949); Maharashtra (Kamat 1963); W. Bengal and Orissa (!).

### 37. *Phacus hispidula* (Eichw) Lemm 1910 (figure 46)

Lemmermann 1910, p. 516; 1913, p. 139, figure 242; Pochmann 1942, p. 238, figure 162.

Cell elongate-ellipsoid with the anterior end slightly retuse and with a short tubular flagellar opening; posterior end with a short straight or sometimes slightly bent tail; cell more or less symmetrical; periplast with longitudinal rows of small forwardly pointed spines; chromatophores small, numerous and discoid; paramylum two lateral pads; eye-spot small to medium-sized; cell (including tail)  $32-40.5 \times 20-22.9 \mu\text{m}$ ; tail alone  $5.3-7.5 \mu\text{m}$ .

*Habitat:* Stray in locations 33 (July), 140, 140a and 142a.

Lemmermann (1913) gives its dimensions as  $33-55 \times 18-33 \mu\text{m}$ .

*Distribution in Indian region:* W. Bengal and Kerala (!).

Other taxa of *Phacus* reported from the Indian region are as follows:

1. *P. abruptus* Korshikov 1928  
from Gujarat (Patel and Waghodekar 1981).
2. *P. acuminatus* (Stokes) Huber-Pestalozzi 1955  
var *discifera* (Pochm) Huber-Pest. 1955—from Gujarat  
(Kamat 1961–62); Maharashtra (Kamat 1975; Kamat and Freitas 1976);  
var *granulata* (Roll) Huber-Pest. 1955  
from Maharashtra (Ashtekar 1982).  
var *indica* (Pochm) Huber-Pest. 1955  
from Burma (As *P. triqueter* (Ehr) Duj-Skvortzov 1937, p. 74, Tafel 10, figure 4  
only); Maharashtra (Kamat 1975);  
var *iowensis* Allerge et Jahn 1943  
Maharashtra (Kamat and Freitas 1976; Ashtekar 1982);  
var *janei* Suxena 1955  
Andhra Pradesh (Suxena 1955). Naidu's (1966, p. 27, figure 20) var *janei* from  
Andhra Pradesh is doubtful since his figure shows only a small central paramylum  
ring instead of the two large rings of unequal size in Suxena's variety, the only  
resemblance between the two being in the size of the cell;  
var *triquetra* Skvortzov 1928  
Maharashtra (Kamat 1968); Gujarat (Kamat 1961–62);  
var *variabilis* Lemm. 1910  
Uttar Pradesh (Hortobágyi 1969);
3. *P. aenigmaticus* Drez 1925  
Andhra Pradesh (Suxena 1955);

4. *P. alatus* Kleos 1881–85  
Burma (Skuja 1949);
5. *P. anacoelus* Stokes 1885 (1888)  
Burma (Skuja 1949);
6. *P. angulatus* Pochmann 1942  
Burma (As *P. alata* var *indica* Skvortzov 1937 and *P. lemmermanni* (Swir)  
Skvortzov 1937 p. 74); Maharashtra (Kamat 1975; Ashtekar 1982);
7. *P. anomalus* Fritsch *et* Rich 1929  
var *pullus-gallinae* Nygaard 1949  
Maharashtra (Kamat and Freitas 1976; Ashtekar 1982). Patel and Waghodekar  
(1981) include this variety under their typical species;
8. *P. bharatii* Hosmani 1976  
Karnataka (Hosmani 1976);
9. *P. brevicaudatus* (Klebs) Lemm. 1910  
Burma (Skvortzov 1937); Maharashtra (Ashtekar 1982);
10. *P. caudatus* Huebner 1886  
var *tenuis* Swirensko 1915  
Gujarat (Kamat 1961–62);
11. *P. cylindraceus* Popova 1976  
Gujarat (Patel and Waghodekar 1981);
12. *P. cylindrus* Pochmann 1942  
Andhra Pradesh (Suxena 1955);
13. *P. dangeardi* Lemm. 1910  
Andhra Pradesh (Naidu 1966); Gujarat (Patel and Waghodekar 1981);
14. *P. fomini* Roll 1925 fa.  
Burma (Skuja 1949);
15. *P. granum* Drez 1925  
Gujarat (Patel and Waghodekar 1981); Maharashtra (Ashtekar 1982);
16. *P. hameli* Allorge *et* Lefèvre 1930  
Maharashtra (Kamat 1963, 1964; Ashtekar 1982); Gujarat (Patel and  
Waghodekar 1981);
17. *P. heimii* var *minor* Suxena 1955  
Andhra Pradesh (Suxena 1955). This variety reported by Naidu (1966, figure 21)  
from Andhra Pradesh is doubtful since he shows in his figure only one paramylum  
ring or two concentric discs whereas both *P. heimii* Lefèvre (1933) (see Pochmann  
1942) and var *minor* Suxena have three disc-like paramylum;
18. *P. horridus* Pochmann 1942  
Maharashtra (Kamat 1963);
19. *P. inconspicuus* Deflandre 1928  
Gujarat (Patel and Waghodekar 1981);
20. *P. indicus* Skvortzov 1937  
Burma (Skvortzov 1937); Andhra Pradesh (Suxena 1955); Himalayas (Subba  
Raju and Suxena 1979); Afghanistan (Hirane 1966);
21. *P. lemmermanni* (Swirensko) Skvortzov 1928  
Burma (Skuja 1949, as *P. alata* var *maior* Drez); Gujarat (Patel and Waghodekar  
1981 as *P. alata* var *lemmermanni* Swir);
22. *P. mangini* Lefèvre 1931  
Maharashtra (Kamat 1975);



23. *P. minutus* (Playf) Pochmann 1942  
Rajasthan (Kamat 1967); Maharashtra (Kamat 1975);
24. *P. musculus* Pochmann 1942  
Gujarat (Patel and Waghodekar 1981);
25. *P. myersii* Skvortzov 1919  
Gujarat (Patel and Waghodekar 1981);
26. *P. oscillans* Klebs 1881–1885  
Burma (Skvortzov 1937); Andhra Pradesh (Seenayya 1972); Gujarat (Patel and Waghodekar 1981);
27. *P. pekinensis* Skvortzov 1925  
Burma (Skvortzov 1937); Maharashtra (Kamat 1964, 1975);
28. *P. peteloti* Lefèvre 1933  
Gujarat (Patel and Waghodekar 1981);
29. *P. platalea* Drez var *minor* Kamat 1961–62  
Gujarat (Kamat 1961–62); Maharashtra (Kamat and Freitas 1976; Ashtekar 1982);
30. *P. polytrophos* Pochmann 1942  
Himachal Pradesh (Kamat 1968a); Gujarat (Patel and Waghodekar 1981);
31. *P. pseudonordstedtii* Pochmann 1942  
Andhra Pradesh (Suxena 1955); Maharashtra (Kamat 1975);
32. *P. pseudoplatalea* var *indica* Kamat 1961–62  
Gujarat (Kamat 1961–62);
33. *P. quinque-marginatus* Jahn et Shawh  
Andhra Pradesh (Naidu 1966);
34. *P. skujae* Skvortzov 1928  
Andhra Pradesh (Suxena 1955; Seenayya 1972); Gujarat (Patel and Waghodekar 1981);
35. *P. spiralis* Allerge et Jahn 1943  
Andhra Pradesh (Naidu 1966);
36. *P. stokesii* fa *minor* Conrad 1938  
Maharashtra (Kamat 1975);
37. *P. strongylus* Pochmann 1942  
Burma (as *P. setosa* var *crenata* Skvortzov 1928–Skvortzov 1937);
38. *P. swirenkoi* Skvortzov 1928  
Maharashtra (Kamat 1975);
39. *P. thrombus* Pochmann 1942  
Burma (Skvortzov 1937, p. 74, Tafel 10, figure 3—as *P. pleuronectes* var *citriiformis* Drez);
40. *P. triqueter* (Ehr) Duj 1841  
Kashmir (Bhatia 1930); Himachal Pradesh (Kamat 1968a); Burma (Skvortzov 1937, p. 74, Tafel 10, figure 5 only; Skuja 1949). Naidu's (1966, figure 22) *P. orbicularis* from Andhra Pradesh measuring 60–63 × 36–37  $\mu$ m and with two ring-like paramylum of equal size and an oblique tail is in all probability only a *P. triqueter* (see under *P. orbicularis* in the text);
41. *P. unguis* Pochmann 1942  
Maharashtra (Kamat 1963; Ashtekar 1982); Himachal Pradesh (Kamat 1968a);
42. *Phacus warszewicksii* Drezepolski 1925  
Andhra Pradesh (Naidu 1966. The figures 26A–B given by Naidu are not typical)

Naidu's *P. trifacialis* Prowse (see Naidu 1966, figure 23) could in all probability be *P. caudatus* Huebner (see text under that species).

### Addendum to Part I—*Euglena* (Philipose 1982)

*Euglena tuba* Carter 1869 non Johnson 1944 emend. Philipose 1982, pp. 585–89, figures 20 a–r and aa–nn

#### Latin diagnosis:

Cellula manifeste metabolica, plerumque, autem, fusiformis ad ellipsoideum cylindricamve, raro fere spherica, extremitate anteriore late rotundata, parte posteriore in acumen obtusum aut caudem brevissimam terminanta, aut saepius, rotundata; pellicula strias tenues spirales punctatas praebens; chromatophora c. 5–16 vel plura, plerumque fusiformia aut manifeste curvata, raro sphaeroidea ad discoidea; omne chromatophorum pyrenoideum bis vaginatum habens; grana paramyli additica parva discoidea in cytoplasmate saepe visum; nucleus sphericus mediusque, fossa stigmaeque satis parvum; flagellum ca.  $1/3$ – $1/2$  longitudinis corporis; haematochroma tempore lucis clarae tetram cellulam, et tempore lucis minuentis extremitatem posteriorem habentes; haematochroma rarissime nulla; cysta ampullae in fundo rotundatae, quae stipitem tubiformem in basim infundibuliformem terminatam habet consimilis; stipis longitudine varians, saepe transverse striatus, et interdum irregulariter articulatus; basis ad oram pilis setiformibus interdum praedita; cystae intra matricem mucosam aggregatae, stipitibus undique eminentibus, aut lateraliter in ordine lineari irregulari inter se adhaerentibus; in statu encystate flagellum nullum; liberatio organismi ruptura ampullae aut in parte media aut propius stipitem aut eius gelatinizatione effecta; post liberationem flagellum breve apparet et longius gradatim factum; flagellum facile exutum; locomotio flagello praesente, libere natante effecta, aut sine flagello, motu lento formae mutationem comitata; cellula plerumque  $(31)–54–74–96 \times 18–30–45 \mu\text{m}$  aut longior, in cellulis fere sphericis, autem  $41.5–56 \times 36–43 \mu\text{m}$ ; cysta  $34–88 \mu\text{m}$ , cum ampulla  $31–47 \times (22.5–)26–47 \mu\text{m}$ , stipis usque ad  $70 \mu\text{m}$  vel longior et  $(8.5–)13–18 \mu\text{m}$  lat., basis  $18–29–32 \mu\text{m}$  diam.

*Habitatio*: Ut spuma rubra vel viridis aut in placto generali aut in luto tenuiter granulose satis frequens ad maxime abundantem in locis 7–9, 21, 24, 32, 45, 50–51, 60, 66, 69, 72–75, 80, 104, 113, 116, 149 et 151 et in aliquot stagnis in locis 61 et 63; cum alteris specibus rubris viridibusve saepe consociata.

One point of interest regarding this species not mentioned in Philipose (1982) is that individuals with discoid chromatophores were seen only very rarely and not in the same collection as those with spindle-shaped chromatophores. While the nature of the chromatophore could not be made out in collections from most locations on account of excess of haematochrome, one cyst measuring  $59 \times 26 \mu\text{m}$  observed in location 151 on 12-7-1938 (see Philipose 1982, figure 20j) and another from location 32 collected on 16-1-1950 and measuring  $73.9 \times 32.3 \mu\text{m}$  had discoid chromatophores. In specimens from location 134 collected in August 1974 the free living individuals showed discoid chromatophores. In location 61 where the organism could be studied during different hours of the day in a number of ponds, the chromatophores were spindle-shaped on most occasions. However, free living individuals in Nursery Pond-16 observed on 18-9-1951 measuring  $40.5–74 \times 26.4–36.7 \mu\text{m}$  had discoid chromatophores (see figure

20 m) whereas those observed in the same pond a few days later (23/26-9-1951) and measuring  $56-70.4 \times 26.3-45 \mu\text{m}$  had spindle-shaped chromatophores (see figure 20n). Both appeared to belong to the same taxon since the pyrenoid was always present in the chromatophores (unlike in *E. orientalis* Walton described below). However, it was not clear why individuals collected within such a short period as five days from the same pond should show different structure especially because there was no visible change in ecological conditions.

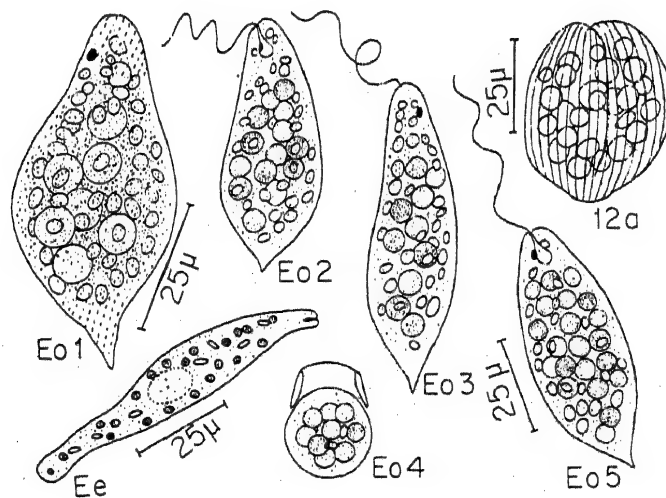
The association of cysts of *E. tuba* with those of *E. tuba* var *pseudotuba* f. *minima* Philipose was also quite frequent in location 61.

Three other species of *Euglena* which could not be included in Philipose (1982) are described below. Additional points on a few specimens already described including minor corrections are also given.

*Euglena orientalis* Walton 1915 (figures Eo1-Eo5)

Gojdics 1953, p. 181; = *Euglena* sp. Kashyop 1908, pp. 111-112.

Cell metabolic but usually cylindrical to ellipsoid and ending posteriorly in a short tail or tail-like process rather abruptly; anterior end rounded; pellicle with faint spiral striae which appear to be punctate; chromatophores green, spherical, of fairly uniform size (about  $6-8 \mu\text{m}$  in diameter) and without pyrenoids, distributed fairly uniformly inside the cell or sometimes with one or both ends free of them; number of chromatophores about 8-21; paramylum numerous, discoid and usually smaller (maximum length about  $5.3 \mu\text{m}$ ) than the chromatophores and more or less uniformly distributed; eye-spot prominent and frequently towards one side at the anterior end; reservoir small with the canal frequently opening slightly towards one side the cell; flagellum about  $3/4$  body length and easily discarded; nucleus not observed; haematochrome present or absent; when present, usually spread over the anterior two-thirds of the cell and light brick red to deep orange in colour; cyst not observed, but a rounded cell with what appeared to be the broken remains of a cyst (see figure Eo4) was seen in one of the collections; cell  $64-80 \times 22-30 \mu\text{m}$ .



Figures Eo1-Eo5. *Euglena orientalis* Walton; Eo4, a rounded cell with broken remains (?) of a cyst loosely attached; Ee. *E. elastica* Prescott; 12a. *Phacus lefevrei* Bourrelly. Figures Eo2-Eo5 under the same magnification.

**Habitat:** As a brick red or green scum or in the general plankton of location 61 (NP 15, November 1953 and February 1954). During February 1954 it appeared as a green scum two days after heavy rains and the cell had no haematochrome (see figures Eo2–Eo5)

The organism agreed fairly well with Kashyop's species measuring  $62 \times 15 \mu\text{m}$  and  $125 \times 31 \mu\text{m}$ , though Kashyop does not refer to the striae as punctate. He does not give the number of the chromatophores, but the largest paramylum is stated to be about  $7 \mu\text{m}$  long. The cyst is described as flask-like as in *E. tuba*. Since the cyst was not observed in the author's material the organism is referred to as *E. orientalis* only tentatively. Kashyop did not observe pure green organisms. However, such individuals were observed in the otherwise brick red *E. tuba* also by the author after heavy rains (see Philipose 1982). Huber-Pestalozzi (1955) regarded this species insufficiently known and hence uncertain.

The organism differs from *E. tuba* with discoid chromatophores in the absence of pyrenoids in the chromatophores and in the presence always of a short tail or tail-like process.

Hortobágyi's (1960, figures 1–10) olive green *E. tuba* with a very short tail, smooth spiral striae, numerous fairly large spherical to oblong chromatophores without pyrenoids, numerous small paramylum, and with dimensions of  $55\text{--}81 \times 20\cdot5\text{--}32 \mu\text{m}$ , could probably be a form of *E. orientalis*.

*E. orientalis* could probably be placed near *E. proxima* under Group Lentiferae because of its fairly large spherical chromatophores without pyrenoids, numerous paramylum which are small or fairly large, its metabolic cell and the presence of a short pointed tail.

**Distribution in Indian region:** Pakistan (Kashyop 1908); Andhra Pradesh (Naidu 1966, figure 15) and Orissa (!). In Naidu's organism ( $60\text{--}91 \times 18\text{--}23 \mu\text{m}$ ) the chromatophores and paramylum are figured as small and discoid and the nucleus as a median spherical one.

#### ***Euglena elastica* Prescott 1944 (figure Ee)**

Gojdics 1953, p. 96, plate 10, figures 3a–b; Huber-Pestalozzi 1955, p. 118, figure 106B.

Cell highly metabolic but mostly spindle-shaped with the median region somewhat swollen and the anterior and posterior ends narrowing abruptly, posterior end rounded conically or frequently knob-like but not extended into a tail; chromatophores numerous irregularly ovoid and without pyrenoids; paramylum also numerous, small and rod-like, and scattered inside the cell; with a fairly large ellipsoid nucleus in the median region; eye-spot and flagellum not observed; cell  $81 \mu\text{m}$  long,  $12 \mu\text{m}$  broad.

**Habitat:** Stray in a weed infested pond (location 100a).

Prescott (as cited by Gojdics 1953) gives its dimensions as  $76\text{--}100 \times 9\cdot5\text{--}11 \mu\text{m}$ . The organism from location 100a agreed well with Prescott's species in most respects but the chromatophores and paramylum were fewer and were scattered all over the cell with the anterior end being free of them at times as in Prescott's figures. Prescott also does not refer to a nucleus.

Naidu (1962, figures 4–6) has reported the species from Cuddapah, Andhra

Pradesh. His specimens measured  $70-75 \times 10-14 \mu\text{m}$ . He states that the paramylum are absent. It is possible that he could not distinguish the paramylum from the chromatophores.

This species can probably be put under Group Lentiferae near *Euglena srinagari* (Bhatia) Huber-Pestalozzi because of its highly metabolic cell and the numerous small chromatophores and paramylum besides an ellipsoid median nucleus.

*Distribution in Indian region:* Andhra Pradesh (Naidu 1962); Karnataka (Dodkundi *et al* 1973; Hosmani and Bharati 1975; 1980); Orissa (!).

***Euglena clara* Skuja 1948 (figure Ec)**

Skuja 1948, p. 190, Tafel 22, figures 12-16; Pringsheim 1956, pp. 84-85, figure 20.

Cell slightly metabolic, elongate oval to nearly hexagonal with almost parallel sides; anterior and posterior ends rounded, the latter end being sometimes slightly truncated; periplast faintly striated spirally; reservoir fairly wide with gradually narrowing canal which opens towards one side of the cell; eye-spot prominent; flagellum about body length or slightly shorter or longer; chromatophores eight or more polygonal or irregular discs with prominent double-sheathed pyrenoids; nucleus spherical, and median or slightly below; cell  $36-40 \times 17-19.5 \mu\text{m}$ .

*Habitat:* In plankton of location 28 (May).

The organism agreed fairly well with Skuja's and Pringsheim's specimens. However, the cells were not as elongate as in their material and resembled the shortened individual figured by Pringsheim (figure 20D). Skuja gives the dimensions as  $35-68 \times 15-19 \mu\text{m}$ . In Pringsheim's material the most frequent sizes were  $55-60 \times 15-17 \mu\text{m}$ . The smaller size in the author's collection was probably because the specimens were juvenile forms freshly liberated from the cyst.

Pringsheim puts this species near *E. polymorpha* Dangeard (1901), under Group Catilliferae.

*Distribution in Indian region:* W. Bengal (!).

***Euglena vaginicola* Philipose 1982**

Philipose 1982, pp. 569-72, figures 6a-b

Philipose (1982) mentioned that in location 33 a few free living individuals which showed a strong resemblance to the organism inside the cyst were found associated with the encysted organism. Figure Ev shows one such individual with the chromatophores arranged spirally and with one slightly elongated and one nearly spherical paramylum in each half of the cell. The faint eye-spot and reservoir seen in some encysted individuals were not observed, nor was there a flagellum. There is a possibility that this organism is really the individual liberated from a cyst. It measured  $57 \times 10.6 \mu\text{m}$ .

***Euglena tripteris* (Duj) Klebs 1883**

See Philipose 1982, p. 572.

Also reported from Afghanistan (see Hirano 1966).

*Euglena srinagari* (Bhatia) Huber-Pestalozzi 1955

See Philipose 1982, pp. 577-80

Under Distribution, omit Kerala and add Tamilnadu.

*Euglena granulata* (Klebs) Schmitz 1884

See Philipose 1982, pp. 582-83, figure 17.

Figure Eg shows figure 17 in Philipose (1982) redrawn with the striae from right to left.

Figure Eg1 is another typical individual.

*Euglena sanguinea* Ehrenberg 1830

See Philipose 1982, pp. 592-93

Under Distribution, add Andhra Pradesh.

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